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# NAVAL POSTGRADUATE SCHOOL

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# THESIS

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**COMPACT DISK TECHNOLOGY AND THE  
CONCERNS OF ATLANTIC FLEET SURFACE  
FORCES COMMANDING OFFICERS**

by

Jeffrey E. Carlson

September 1994

Thesis Co-Advisors:

Patrick J. Parker  
William B. Short

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COMPACT DISK TECHNOLOGY AND THE CONCERNS OF ATLANTIC  
FLEET SURFACE FORCES COMMANDING OFFICERS

by

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Submitted in partial fulfillment  
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY  
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## ABSTRACT

This thesis deals with the concepts of Compact Disk (CD) technology, OPNAV INST 5230, and the concerns of the Commanding Officers of the surface forces of the Atlantic Fleet. OPNAV INST 5230 is the Navy and Marine Corps guidance on the implementation of CD technology. Review of current literature indicates the minimum requirements of the instruction are insufficient. Methods of improvements are discussed. Using the Systems Development Life Cycle as a framework, three methods of implementing CD-ROM technology are proposed. Management concerns are addressed, specifically, resistance to change when implementing a new technology. An economic analysis is also included. Commanding Officers of surface ships are surveyed to determine the extent of CD usage on ships, the types of training involved with their usage, concerns over the systems and the desire to participate in a pilot program should one be funded.

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## I. INTRODUCTION

### A. COMPACT DISK TECHNOLOGY

Compact Disk (CD) technology is becoming the preferred media for digital storage of massive amounts of information. CD-ROMs can hold up to 70 times the amount of data a normal computer diskette can contain.<sup>1</sup> CD-ROM based technology is helping in the distribution of information and is becoming the most popular means of storage, presentation and distribution of data. The information stored on CDs is in a digitized format allowing any type of data, i.e., text, graphics, sound, animation and video to be placed onto the disk. The combination of various media onto a single disk is known as multimedia.<sup>2</sup>

CDs for computer usage are a result of audio CD in the music industry. Both types of CD, audio and computer, follow a rigid set of international standards for compatibility and usage. This is to protect the user and the CD industry by ensuring compatibility of software, hardware and peripheral equipment. The usage of CDs by computers has evolved into

---

<sup>1</sup>Harmon, A., "Sales of CD-ROM soared at the end of 1993; falling prices for computers, CD-ROM drives drive holiday software sales", *Los Angeles Times*, March 29, 1994.

<sup>2</sup>Rasmussen, C., "CD-ROM takes centre stage", *Computing, Canada*, v20 n5 p35(1), 2 March 1994.

several major areas. These areas involve:

- COMPACT DISK-INTERACTIVE (CD-I) a format that combines audio, visual, still and full motion video, and animated graphics, allowing the user to become an active participant in the use of media. CD-I is rapidly becoming the media of choice for education and training.
- COMPACT DISK-WRITABLE (CD-R) enables the users to create their own disks and update the data when needed. It offers a low cost archiving system for production and testing of multimedia. A CD-R disk can hold as much as 650 megabytes of data and cost approximately \$20. Comparably, 460 floppy disks with a capacity 1.4 megabytes each and a cost of about \$600 would be required to hold the same amount of data<sup>3</sup>.
- COMPACT DISK-READ ONLY MEMORY (CD-ROM) is the most prevalent CD media for storage of data. Text, graphics and audio are placed on the media for the user to view and hear. It is not interactive
- COMPACT DISK-EXTENDED ARCHITECTURE (CD-ROM/XA) is a type of CD-ROM. It allows for text and video to be viewed and narrated at the same time. XA compresses and weaves sound among the video, text and other data within the same file. The XA drive will play standard CD audio, CD-ROM and XA format disks<sup>4</sup>.

These areas are rapidly developing in the business arena and are of great interest to the Navy.<sup>5</sup>

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<sup>3</sup>Holsinger, E., "Make your own CD-ROMs", *MACUSER*, v10 n6 p100(8), June 1994.

<sup>4</sup>Gilder, J. H. and Newton, H., "A simple(?) Explanation of CD-ROM Drives Part 1", *Imaging Magazine*, February 1993.

<sup>5</sup>Department of the Navy, OPNAV INSTRUCTION 5230, *NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY*, November 1993.

## B. DEPARTMENT OF THE NAVY POLICY FOR CD

The United States Navy initiated the introduction of CD technology with a massive acquisition and Life Cycle Support project that converted all technical documentation for the Trident submarine into a set of 350 plus Compact Disks (CD). The technology is now expanding to all areas of the fleet. The CD technology includes CD-ROM and writable CDs that follow the International Standards Organization (ISO) 9660 standard.<sup>6</sup> To guide the fleet in implementing the new technology, the Navy has issued *OPNAV INSTRUCTION 5230, NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY*. The purpose of the instruction is to assist in the smooth and effective transition to CD technology as the preferred media for storage and dissemination of information and data for the Navy and the Marine Corps.<sup>7</sup> The instruction provides minimum guidance for implementation of CD technology and does not discuss any underlying factors to be reconciled when implementing and managing a new technology.

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<sup>6</sup>Olsen, F., "Navy gives CDs an edge over paper; new policy dubs CDs 'preferred media for future publications", *Government Computer News*, v12 n26 p1(2), 6 December 1993.

<sup>7</sup>Department of the Navy, *OPNAV INSTRUCTION 5230, NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY*, November 1993.



## **C. OBJECTIVES**

This thesis involves an examination of Compact Disk (CD) technology, its methods of application, and management of the technology onboard U.S. Naval vessels. A System Development Life Cycle (SDLC) for CD usage will be proposed.

## **D. SCOPE, LIMITATIONS, AND ASSUMPTIONS**

### **1. Scope**

The research is limited to current CD technology that is available for purchase. The surface forces of the U.S. Atlantic Fleet, commissioned prior to 1992, were blanket surveyed for inputs on current CD usage and concerns for shipboard use of CD technology. Standardization of hardware and software is not discussed since these issues are resolved through International Standards Organization (ISO) 9660 and the American National Standards Institute (ANSI) Rainbow Series of Standardization.

### **2. Limitations**

Current administrative restructuring and drawdowns in force structure may have prevented mailed surveys from being delivered in time for inclusion and analysis in the study.

### **3. Assumptions**

It is assumed the reader is familiar with OPNAV INST 5230 and has a minimal background in computer usage. Familiarity with computer technology and terminology will help in understanding the concepts of the research.

## **II. COMPACT DISK INFORMATION SYSTEMS**

### **A. A BASIS FOR A COMPACT DISK INFORMATION SYSTEM**

The transition to storing media on compact disks and implementing CD technology on surface ships has changed the basic way desk top computers have been used onboard vessels. Prior usage included: report generation, generation of small databases and transaction processing. Now, emphasis is on the improvement of personnel and shipboard performance (an underlying objective of OPNAV INST 5230) through CD technology. Improvement of the command performance is accomplished through the crew. Therefore, the focus of the command should be on improvement of personnel, the end user.<sup>8</sup>

### **B. COMPONENTS OF A COMPACT DISK INFORMATION SYSTEM**

#### **1. End User**

The end user, or user, is often the most overlooked component of an information system. Developers must always remember that the system should be designed for the end user.

---

<sup>8</sup>Sprague, R. H., Jr., and McNurlin, B. C., *Information Systems Management in Practice*, 3rd ed., pp. 13-14, Prentice Hall, 1993.

If the system is too difficult, the end user will be less likely to work with it.<sup>9</sup>

## **2. Methods and Procedures**

Methods refer to the way the information is processed. Processing is conducted in one of three ways: batch, interactive or real time. Batch processing requires data to be accumulated and periodically processed, i.e. a payroll file for disbursing. Interactive processing (on-line processing) requires data to be processed as it occurs and becomes available. Real-time processing requires rapid response times, i.e. target tracking and acquisition.

Procedures are concerned with how the end users complete their task and how decisions are made. These procedures do not refer to software program procedures but procedures for the end user. How data is collected and entered, how reports are distributed, and what decisions and activities are the responsibilities of the end user are types of procedures.<sup>10</sup>

## **3. Computer Hardware**

Computer hardware onboard a ship includes but is not limited to: optical scanners, printers, cathode ray tubes (CRT), magnetic disk storage devices, CD drives, CD-R

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<sup>9</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 61, Irwin, 1989.

<sup>10</sup>Ibid, pg. 62.

recorders, and central processing units (CPU). The hardware arena is a dynamic environment, in a continual change.<sup>11</sup>

#### **4. Computer Software**

Software is the program code which performs a specific function that supports the end user. It can either be purchased in a preprogrammed software package, or be customized for the individual user. Software for CD systems may be purchased with the system and installed by the user for immediate integration into the system and configuration files. This prevents users from entering into the programming and making unnecessary or damaging modifications to the system.<sup>12</sup>

#### **5. Data Storage**

Data storage is a basic component of a CD system. How the data is stored, in what format, and the integration of the data are key elements of the data base. Redundancy should be kept to a minimum and the structure should be changeable without the entire database being changed.<sup>13</sup>

### **C. PURPOSE OF A COMPACT DISK SYSTEM**

The purpose of a CD system is supporting the information requirements of the end user. This requires a knowledge of the information in storage and an understanding of what

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<sup>11</sup>Ibid, pg. 63.

<sup>12</sup>Ibid, pg. 63.

<sup>13</sup>Ibid, pg. 65.

composes information by the end user. Data, or raw facts, when isolated have no apparent meaning and are not useful to a user. On the other hand, information, or data that has been manipulated, is useful to a user. Information to one user, however, may not be information to another user.<sup>14</sup> The collection and compilation of information will be crucial when collecting and transferring technical manuals, logs and other shipboard documentation onto CD media. A standard format for the data must be devised prior to transferring the data. In order to develop information that is easily understood by everyone, including the various inspection teams, naval commands should be thoroughly interviewed as to the importance of each piece of data prior to conversion.<sup>15</sup>

#### **D. TYPES OF COMPACT DISK INFORMATION SYSTEMS**

##### **1. Compact Disk-Recordable (CD-R)**

CD-R is a user recordable CD. It is a method of CD-ROM where the user develops and records multimedia onto a CD. Functionally, CD-R and CD-ROM media are the same. The recorded disk is capable of being played on a standard CD-ROM player.<sup>16</sup>

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<sup>14</sup>Ibid, pg. 51.

<sup>15</sup>Department of the Navy, OPNAV INSTRUCTION 5230, *NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY*, November 1993.

<sup>16</sup>Schroeder, E., "CD-R is becoming a storage option", *PC Week*, v11 n11 p33(2), 21 March 1994.

**a. What is CD-R**

CD-R is an outgrowth of the CD-ROM industry. The recent explosion of CD-ROM interests has lead to the development of recordable media where the user can store data directly to the disk for distribution. The federal market for CD-R has been limited to purchasing one or two systems at a time. The Army, however, has recently installed the Paperless Document Imaging Management System which promises to have a big impact on the production of CD-R for the federal agencies.<sup>17</sup>

CD-R is attractive for updating small amounts of information that changes frequently. The technology is also attractive because the user manufactures the disks inhouse. Current cost effective uses for CD-R are:<sup>18</sup>

- Data archival.
- Low volume, time sensitive data.
- Inexpensive mass storage for network and work group applications.
- Decision Support Systems (DSS).
- Knowledge bases for Expert Systems.
- Secure data distribution.
- Test publishing in advance of mass replication.

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<sup>17</sup>Lazar, J., "CD-writable tech poised for explosive growth", *Federal Computer Week*, v7 n13 p20(1), 7 June 1991.

<sup>18</sup>McCormick, J., "Roll your own CD applications with CD-R drive set-ups", *Government Computer News*, v12 n20 p29(2), 20 September 1993.

### **b. Types of Recordable CDs**

There are two types of recordable CDs: CD-R and CD-Write Once Read Many (WORM). CD-R has an advantage over CD-WORM because CD-WORM lacks standardization. CD-R disks can be read in any CD-ROM reader. CD-WORM's are proprietary, requiring drives from the same manufacturer whose equipment was used to record the disk to be used in reading the disk. Use of proprietary equipment should be avoided and open systems standards should be used.<sup>19</sup>

### **c. Intent of CD-R Systems**

The intended purpose of recordable CDs, in the context of OPNAV 5230, is for use by large commands where it is economically feasible to produce volumes of information. Commands such as Naval Sea Systems Command (NAVSEA) or the Naval Tactical Support Command (NAVTACSUPPCOMM) which publishes the Naval Warfare Publications (NWP) Series, both classified and unclassified publications potential users.<sup>20</sup>

## **2. Compact Disk-Interactive (CD-I)**

CD-I uses a laser beam technology that reads video data from 5.25-inch disks and transmits the data directly to a television. The unique system requires user interaction with cumbersome and slow multimedia software that is not

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<sup>19</sup>Hill, J., "Write-once archiving with CD-R", *PC Magazine*, v13 n9 p155(1), 17 May 1994.

<sup>20</sup>Telephone conversation between Greg Vellott (Naval Tactical Support Activity) and author, 3 August 1994.

compatible with CD-ROM technology. It is primarily used in games and entertainment, but there is confusion over determining what CD-I is: a game, a computer or a video player. Actually it is all three.<sup>21 22</sup>

### **3. Compact Disk-Read Only Memory (CD-ROM)**

#### **a. What is CD-ROM**

CD-ROM is an excellent media for storing large amounts of textual and graphical information. It is used for multimedia games, references, operating systems, graphics packages, and programming tools.

#### **b. Types of CD-ROM**

CD-ROM drives can be either internal, external, or portable to the computer.

(1) *Internal Drives.* Internal drives are similar to the floppy, hard or tape drives permanently installed on the computer. The drives are a permanent part of the computer, need a stable environment to nestle in and rely on the host computer for a power supply.<sup>23</sup>

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<sup>21</sup>Du Bois, M. R., "Early Casualty?", *The Wall Street Journal*, March 21, 1994, pr19(W)pr(E)col 1(26(col 9n).

<sup>22</sup>Hutheesing, K., "Betamax versus VHS all over again?", *Forbes*, January 3, 1994, v153, n1 p88(2).

<sup>23</sup>Benford, T., "Double-Speed CD-ROM Drives: A Buyer's Guide (and More!)", *CD-ROM Today*, pg. 37, April/May 1994.



(2) *External Drives.* External drives are housed in their own cabinet for portability among one or more computers and across different platform types. The power supply and external casing cost more to produce so the external drives are proportionately more expensive. External CD-ROM drives require either Small Computer System Interface (SCSI) or parallel port connectors. The external drives provide connectors for attachment of the interface cables. The parallel port connector interface sacrifices speed for universal compatibility and is significantly slower, performing poorly on multimedia applications, and the worst in independent testings. The poor performance is a result of a bottle neck in the flow of data from the CD-ROM drive to the system CPU. Processing time can reach 60% of the CPU processing power.<sup>24 25 26 27</sup>

Purchase of some external double speed drives may require battery packs for power. However, the manufacturers of the battery powered drives no longer manufacture batteries

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<sup>24</sup>Quain J., "Going Mainstream", *PC Magazine*, v13 n4 p110(22), 22 February 1994.

<sup>25</sup>Pastrick, G., "Liberty 115CDP", *PC Magazine*, v13 n4 p128(2), 22 February 1994.

<sup>26</sup>Quain J., "Going Mainstream", *PC Magazine*, v13 n4 p110(22), 22 February 1994.

<sup>27</sup>Benford, T., "Double-Speed CD-ROM Drives: A Buyer's Guide (and More!)", *CD-ROM Today*, pg. 37, April/May 1994.

which may lead to problems with lack of support in the future.<sup>28</sup>

(3) *Portable Drives.* Portable drives offer the most flexibility and convenience for CD-ROM. They are smaller, lighter, and comparable to the portable CD audio players currently on the market. Models come with SCSI interface and battery packs.<sup>29 30 31</sup>

### **c. CD-ROM Drive Speed**

(1) *Single Speed.* Single speed CD drives meet the Multimedia PC Marketing Council (MPC) Level 1 specifications for transferring data at 150 Kbps or faster and use no more than 40 percent of the Central Processor Unit (CPU) processing power. The requirements for CD-ROM drives specified in OPNAV INST 5230 require, as a minimum, Multimedia Personal Computers (MPC) Level 1.<sup>32</sup>

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<sup>28</sup>Chen, S., "CD Porta-Drive Model T3401", *PC Magazine*, v13 n4 p116(2), 22 February 1994.

<sup>29</sup>Benford, T., "Double-Speed CD-ROM Drives (buyers guide)", *CD-ROM Today*, pg. 40, April/May 1994.

<sup>30</sup>Ibid, pg. 41.

<sup>31</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242(6), v12 n4, April 1994.

<sup>32</sup>Department of the Navy, OPNAV INSTRUCTION 5230, NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY, November 1993.

(2) *Double Speed.* Double speed drives meet the MPC Level 2 specifications of 300 Kbps with the drive using no more than 60 percent of the CPU processing power.<sup>33</sup>

(3) *Triple and Quad Speed.* Triple and quad speed CD-ROM drives are being tested on the commercial market. Their advantage is the faster retrieval rate of 450 KBPS and 600 KBPS respectively.

**d. Multimedia Personal Computer (MPC) Standards**

MPC standards are set to ensure current multimedia titles can run effectively on a computer. In order to meet minimum MPC level 2 standards, the computer with a CD-ROM installed should meet or exceed the following requirements:

- 25 Mhz
- 486SX PC or better
- minimum of 8MB of RAM
- VGA display to meet MPC Level 2 standard
- minimum 160MB Hard disk

These minimum requirements conflict with the minimum user requirements as set forth in OPNAV INST 5230 for computer Operating Systems(O/S). The OPNAV instruction requires less hard disk space, less RAM and a less powerful computer.<sup>34</sup> Installation of the appropriate drivers and software typically

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<sup>33</sup>Quain J., "Going Mainstream", *PC Magazine*, v13 n4 p110(22), 22 February 1994.

<sup>34</sup>Ibid.

requires 500Kbytes of hard disk space. Reference titles may take up to 1MB of hard disk space to store such things as navigation files and frequently used graphics. Some may need as much as 8MB of hard disk space. The lesser standards of OPNAV 5230 will result in the overall performance of the CD-ROM system being degraded in response time and capabilities. In cases where disk space is required, systems without the requisite amount of space will not be capable of using the software.<sup>35</sup>

Other problems also exist. Smooth video playback at fifteen frames per second for 320 by 240 pixel compressed video is still difficult for many players. Audio dropout still occurs on slower speed drives. SCSI is the interface chosen by most manufacturers because of dataflow improvement. The parallel port connections offer transportability and freedom from SCIS configuration hassles but result in limited throughput because of the serious data flow bottlenecks.<sup>36</sup>

#### **4. Compact Disk-Read Only Memory/Extended Architecture (CD-ROM/XA)**

CD-ROM/XA is an extended architecture of the CD-ROM disk format. CD's are formatted into tracks. Each track has a mode to describe the type of data it contains. Mode 0 holds conventional audio, Mode 1 contains computer data and Mode 2,

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<sup>35</sup>Quain J., "Going Mainstream", *PC Magazine*, v13 n4 p110(22), 22 February 1994.

<sup>36</sup>Ibid, pg. 110.

seldom used, is designated for user data, which allows the mixing of data types into a single track. The standard Mode 2 is redefined in XA. Each sector, a data block, in Mode 2 includes a subheader describing the data. The Form 1 subheader is for computer data and the Form 2 subheader is for audio.<sup>37</sup>

An XA formatted disk can hold up to 18 hours of audio. When the audio is interleaved, i.e. a mixture of Form 1 data sector and Form 2 audio sectors, the computer can separate the computer data from the audio data. The XA compatible drive can send data to the computer at the same time it's playing audio, a process that is not possible for some CD-ROM drives incompatible with XA format.<sup>38</sup>

CD-ROM/XA is an alternative format for low cost CD drives that have limited RAM and no hard drive. The elements of the disk are pre-synchronized and interleaved into an extended architecture data stream. The elements come off the disk at the appropriate time for use. This type of presentation allows a continuous reading of the disk at the highest possible speed.<sup>39</sup>

The CD-ROM/XA format and compatibility requirements appear to be losing interest in the industry. Very few XA

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<sup>37</sup>Victor, T., "CD-ROM/XA and Multi-Session: Bound to be the Very Next Phase", *CD-ROM Today*, pg. 63, Fall 1993.

<sup>38</sup>*Ibid*, pg. 64,

<sup>39</sup>*Ibid*, pg. 66.

titles can be found and MPC Level 2 requires CD-ROM drives to only play back XA files.<sup>40</sup>

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<sup>40</sup>Quain, John, "Going Mainstream", *PC Magazine*, v13 n4 p110(22), 22 February 1994.

### **III. DEVELOPING A COMPACT DISK SYSTEM**

#### **A. ORIGINS OF A COMPACT DISK SYSTEM PROJECT**

A project starts as a reaction to a problem. For the Navy, the volumes of documentation that are stored on a surface ship take up critical space and involve tons of excess weight that hamper the shipboard damage control efforts. In addition, the need for more document storage is growing because of the complexity of the shipboard environment. The situation is undesirable and can reduce a Commands ability to achieve its military mission because of lost or missing information, or creating personnel hazards present during extreme situations such as heavy weather where the excess weight affects stability and the haphazard storage of the volumes of documentation may shift and injure personnel! The problems with the document storage onboard ships are not new, but until recently, technology has not produced a practical solution. The opportunity appears to be CDs. The low cost, long shelf life and storage capabilities of the disks and CD technology provide an opportunity to alleviate the massive data storage and retrieval problems for the Navy. The definition of a problem and the opportunity for acceptance

usually results in a directive from higher management.<sup>41</sup> The Navy is no exception and OPNAV INST 5230 is the Navy's governing directive on CD technology.<sup>42</sup>

## B. PIECES

Problem descriptions, classification, the opportunities they present, and the resultant directives when implementing a system are best described by James Wetherbe's acronym "PIECES", with each letter standing for a category of opportunity:

- improving **performance**
- improving **information**
- improving the **economics** and cost controls
- improving **control** and security
- improve **efficiency** of people and computers
- improving the **service** to others

The various categories of the PIECES framework are related. One or more categories may portray any project and is a practical framework to start in the description of any

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<sup>41</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 81, Irwin, 1989.

<sup>42</sup>Department of the Navy, OPNAV INSTRUCTION 5230, NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY, November 1993.



problem, keeping in mind the PIECES framework in each phase.<sup>43</sup>

### **C. THE SYSTEM DEVELOPMENT LIFE CYCLE (SDLC)**

The process of developing and maintaining a CD system throughout its useful life cycle is termed the System Development Life Cycle (SDLC). The SDLC is the management tool a command uses to plan, execute, and control the development of the CD system. It follows six basic principles:<sup>44</sup>

1. The CD system is for the end user, in this case the sailor on the ship. The end user is the one who will benefit the most from the use of the CD system. If the system is confusing, difficult, or not user friendly, end user acceptance for the CD system will be difficult.
2. Establish Phases and Tasks. The SDLC consists of phases. Each phase requires work and time to be invested. Using a phased approach prevents haphazard production of CD systems that may require more costs and time to be invested at a later date because of CD system errors and requirement steps being overlooked.
3. Systems Development is not a Sequential Process. Each phase of the SDLC need not be completed prior to the start of the next phase. Tasks can be paralleled with the knowledge that tasks and requirements may change. Each phase must be completed to measure the progress of the CD system development.

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<sup>43</sup>Wetherbe, J., *Systems Analysis and Design: Tradition, Structured, and Advanced Concepts and Techniques*, 2d ed., West, 1984.

<sup>44</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 81, Irwin, 1989.

4 CD Systems are Capital Investments. The CD system to be developed or purchased no matter how small in costs, should always be considered a capital investment. Always look for several possible solutions and identify alternative solutions for cost effectiveness and feasibility. Cost effectiveness is balancing the development costs, with the operating costs, and the benefits gained from the CD system.

5. Never be afraid of Cancellation. The phased approach to the development of the CD system allows decision opportunities for continuation of the system development. There is an inherent tendency to not cancel a CD system development project because of the time and money already invested. This is a poor economic decision. The cost is a sunk cost and should not influence future considerations. At each decision point in development, the CD system should be reevaluated for feasibility.

6. Document all phases. Document every process during the work, such as vendors contacted, help given, or products investigated. The importance is to document the data as the system is being developed, not to document after the completion. Well documented systems show the strengths and weaknesses of the CD system to others and the value of the documentation is when problems develop after developers have moved on to new commands.

The basic principles are guidelines to follow. Whether building a complete CD computing environment or upgrading with a multimedia kit, the premise remains the same.

#### **D. PHASES OF THE SDLC**

As discussed in the previous section, the SDLC is composed of phases that are used to develop the CD system. There are three ways in which to develop a CD system:<sup>45</sup>

- Develop the CD system with individual components.

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<sup>45</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 23, Spring 1994.

- Install a multimedia upgrade kit to an existing Personal Computer (PC).
- Purchase a PC with a CD-ROM drive installed.

An understanding and application of the phases will help in the production of the CD system in one of the three ways.

## **1. Survey Phase**

### **a. Description**

The preliminary investigation into the feasibility of producing a CD system is the survey phase. The purpose of the investigation is to assess whether or not a CD system is needed and if significant resources exist to establish a CD system. Using the PIECES framework of improvement, security and control, efficiency, and service, the scope of the project is defined, end-users are identified, and the perceived problems, opportunities and solutions are identified. The output of the assessment is the feasibility statement that contains the findings and recommendations.<sup>46</sup>

### **b. Shipboard Survey Phase**

During the survey phase, the command initiates an economic analysis of the project and determines if an adequate amount of funding is available. The department and divisions are identified as end users. Problems which may arise could be (but are not limited to) security and management of the

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<sup>46</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 89, Irwin, 1989.

system, future upgrades, networking, and use of uninterrupted power supplies (UPS) for the loss of electrical power. Opportunities may focus on assistance from the Type Commander (TYCOM), salvage of equipment from decommissioning units, or receiving additional funding for the project.

## **2. Study and Analysis Phase**

### ***a. Description***

During the study phase the current system(s) onboard a ship are examined for their present and future capabilities with a CD system installed. Current problems are identified and solutions proposed. This phase requires a thorough understanding of the system(s). The findings of the study phase are problem statements for the next phase of the life cycle. A formal report can be used or an updated feasibility document will suffice. Layout of the formal report can follow the PIECES format for easier reading and relatability. The importance is the documentation. The command can then cancel or continue on with the development of the new CD system based on its feasibility.

### ***b. Shipboard Study and Analysis Phase***

The shipboard study and analysis phase requires surveying the existing computers on the ship. The present capabilities of each computer is documented. The working environment should be a consideration when purchasing a CD-ROM system. If the environment is smokey or has excessive dust,

consideration should be given to a drive mechanism with double doors and a caddy design for protection of the mechanism. Caddyless tray designs that work like audio CDs are more convenient and the majority of the CD drives have a self cleaning lens to keep the mechanism on track. External drives are slightly more expensive than internal units but should be considered if the present computer system(s) is short of space. The physical shape of the computer also needs consideration. It may be a desk top model, a mini tower, or full standing tower. External, portable drives can be connected to other computers if they contain the same interface card. If the computers are below the minimum requirements, then an upgrade or replacement is needed. Current problems the command is experiencing with the ships computer system(s) is documented. For example, the effects of the degaussing coils (used to reduce the magnetic signature of the ship as an anti mine warfare capability) could impact the system. A tentative solution would be moving the computer to a new location or shielding the computer in its present location.

### **3. End User Requirements Phase**

#### **a. Description**

The end user requirements phase is used to determine the needs of the end user. Modeling or prototyping

may be used in development of a new system.<sup>47</sup> The end user requirements are partially defined by the system requirements of OPNAV INST 5230.<sup>48</sup> However, current literature recommends more powerful CD computing systems (ships presently have computers that meet or exceed the system requirements of OPNAV INST 5230).<sup>49</sup> Some end user requirements that need to be determined on a ship include: what types of outputs (hardcopies) are needed, how much storage space is required, where the systems should be placed to ensure maximum utilization among the crew, which crew members require training on the system, when to upgrade the system, and what the disks formats should be. The read format of the disk layout should be familiar to the end user and easy to understand.<sup>50</sup>

***b. Shipboard End User Requirements***

The shipboard end user requirements will vary from department to department. Use of a CD-ROM in the operations department will require tighter security measures due to the availability of classified material. CD-ROMs may require

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<sup>47</sup>Department of the Navy, OPNAV INSTRUCTION 5230, NAVY AND MARINE CORPS POLICY ON THE USE OF COMPACT DISK TECHNOLOGY, November 1993.

<sup>48</sup>Ibid.

<sup>49</sup>See paragraph II.D.3.d., MPC Standards.

<sup>50</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 93, Irwin, 1989.

isolation to ensure information security. Use of CD-ROMs in the Combat Information Center (CIC) will require backup power sources for Uninterrupted Power Supply (UPS) in the event of the shipboard electrical power plant failure.

#### **4. Selection of a Feasible Solution Phase**

##### **a. Description**

During this phase, the selection of alternatives does not require knowing all the specific details of each alternative. Instead, each alternative is evaluated on:

- Technical Feasibility: Is it technically practical?
- Operational Feasibility: Will the CD system satisfy the command's and OPNAV INST 5230 requirements? How will the CD system change the work environment, and how do the end users feel about the new technology?
- Economic Feasibility: Is the solution cost effective to the command?

The infeasible candidates are eliminated, the decisions are recorded and the final output is the approved CD system to be implemented.<sup>51</sup>

##### **b. Shipboard Feasibility Phase**

Shipboard feasibility is conducted in the same areas:

- Technical Feasibility. Do the Electronic Technicians (ET) have the requisite knowledge to implement the CD-ROM systems? Are there other commands that can provide

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<sup>51</sup>Ibid, pg. 93.

assistance? Are there systems that can meet the rugged environmental conditions onboard ship?

- Operational Feasibility. Do the CD-ROM systems currently being evaluated satisfy the constraints of OPNAV INST 5230? What are the anticipated changes in the work center from the use of the CD-ROM, and is the command capable of devising and instituting a training program?
- Economic Feasibility. Is the purchase of the CD-ROM system based on sound economic analysis, and will the command have funds to maintain the system?

## **5. Acquisition of the Hardware and Software Phase**

### ***a. Description***

The acquisition of CD system hardware and software should begin before the construction of the system to prevent delays in scheduling. The Command must determine which specifications are most important. Meeting the minimum standards that are required will not suffice for the future. The fact that the CD and computer industry are rapidly changing requires forethought in the purchase of a component or a system in total. When selecting CD system components, choose the fastest model with the highest transfer rates and the lowest access time. Choosing an average performer because of price will result in inadequate performance in a few short years. Performance is also a cost issue, however if the Command can afford the expense it is well worth the investment.<sup>52</sup>

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<sup>52</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 32, Spring 1994.



***b. Shipboard Acquisition of Hardware and Software***

(1) *Upgrading.* Upgrading a current system to CD-ROM assumes the Command has a Personal Computer (PC) that's capable of handling the CD upgrade. CD applications will continue to improve, becoming more sophisticated, demanding more of the Central Processing Unit (CPU) with time. Upgrading to a 486 or Pentium based CPU is a decision to consider. When upgrading, consider the motherboard. Some motherboards allow replacement of 80386 chips with 486 types. Though not all motherboards allow this upgrade, it is a less costly option than getting a bigger CPU. If attempting to upgrade from the mother board, check owners manuals first to confirm the motherboard can accept a 486 chip. For 386 motherboards that do not accept the upgrade, purchase of a whole new motherboard may be the next inexpensive option for the upgrade. Purchase of a new motherboard still allows the reuse of floppy and hard drives, RAM, system case and monitor. The upgraded motherboard should have the essential components needed for the CD system. Components needed include serial and parallel ports and an integrated local bus for video capabilities.<sup>53</sup>

(2) *Random Access Memory (RAM).* Upgrades in RAM are required for accommodating the multimedia aspects of CDs. Generally, a 486 based machine comes with a base configuration

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<sup>53</sup>Ibid, pg. 24.

of 4MB of RAM. For good multimedia performance at least 8MB of RAM is needed and 12MB to 16MB is more desirable. Use of Windows based software will require as much RAM as the motherboard can accommodate.<sup>54</sup>

(3) *Hard Drives.* Large hard drive disks are needed for Full Motion Video (FMV) and quality audio CDs. FMV is transferred to the hard drive to avoid lag time of data transfer from the disk to the screen. The hard drive acts as a buffer for the data. 200MB hard drives are common but upgrade to the largest hard drive the Command can afford. An option to purchasing a new larger hard drive, is the addition of a second hard drive to gain the additional storage needed for the CD-ROM system.<sup>55</sup>

(4) *CD-ROM Drives.* Selection of a CD-ROM drive is a matter of choice. The choices should include the requirements and budget decisions documented in the Feasible Solution phase of the SDLC. The prevalent CD-ROM drive(s) on the market is the double speed drive. The double speed drive spins at faster than the normal speed of 150 KBPS when accessing information and spins at the normal speed of 150 KBPS for audio transfer rate. A rule of thumb is, the higher the transfer speed, the smoother the data flow. Transfer speeds are always represented in kilobytes per second. The

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<sup>54</sup>Ibid, pg. 25.

<sup>55</sup>Ibid, pg. 25.

higher the data transfer rate (the speed at which the CD-ROM drive moves data from the disk to the PCs memory) the better the performance of the drive.<sup>56</sup>

Access time, represented in milliseconds (msec), is how long it takes to access the data. It deals with the recovery rate of data, and for a CD-ROM system it needs to be low. A 200msec drive is fast. 300msec is the current market average. Compared to the normal access time of a hard drive, 20msec, a CD-ROM drive is considerably slower. When access times are compared look for the lower number for faster performance.<sup>57</sup>

(5) *Internal, External, and Portable CD-ROM Drives.* The discussion of the three types of CD-ROM disk drives was given in paragraph II.D.3.c. In a shipboard environment, the command must be concerned with dust and the CD-ROM drive. CD-ROM drives come with automatic lens cleaning, a dust protection door, and an emergency eject to prevent damage to the drive which can be caused by excessive dust.<sup>58</sup>

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<sup>56</sup>Benford, T., "Double-Speed CD-ROM Drives: A Buyer's Guide (and More!)", *CD-ROM Today*, pg. 37, April/May 1994.

<sup>57</sup>Ibid, pg. 37.

<sup>58</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242(6), v12 n4, April 1994.

(6) *Video.* Video is an important part of the CD-ROM system. Super VGA (SVGA) with a minimum of 1MB of video RAM should be considered when upgrading. The SVGA has a screen of 800x600 pixels and 256 colors. The SVGA is a minimum standard for MPC Level 2 when using multimedia applications on the system because it prevents screen flicker for easier viewing. OPNAV INST 5230 requires as a minimum, a VGA color terminal with the graphic capabilities which may flicker.<sup>59</sup>

(7) *Sound Cards.* Sound card selections are: Frequency Modulated (FM) synthesis chip or the use of a wavetable generator with a Digital Signal Processor (DSP card). An FM sound generator card is used for mid range sound and retails for under \$200.00. FM sound cards include a joystick port and the ability to accept input from a microphone and a line level source such as a CD-ROM drive. A higher quality sound card utilizes the wavetable sound generator and DSP. The wavetable uses digital reproduction instead of FM synthesis. This enables a complexity of sounds to be delivered. DSPs are capable of 16 bit sampling rates at 44.1 kilo Hertz (khz) which is important for CD audio. The sampling rate is the number of times per second the sound card checks the frequency of incoming sound waves while converting

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<sup>59</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 25, Spring 1994.

them to a digital format. A 44.1khz sound card samples 44,100 times per second. One minute of 16 bit sound sampled at 44.1khz takes up over 10MB of the hard disk. A wavetable card offers the possibility of expanding memory to increase voice capabilities. Wavetable cards have an FM synthesis chip to ensure capability with software designed for FM based cards. The DSP handles the work the CPU would normally process with complex audio functions. If the CPU were to handle the audio functions, system performance would be adversely affected by a reduction in response time. DSPs are upgradable which extends the life of the sound board.<sup>60</sup> Very high end sound cards feature recording capabilities and compression options. They are professional sound cards which can exceed \$600.00 and deliver top performance.<sup>61 62</sup>

(8) *Audio Input and Output Items.* Audio input and output items accompany most sound cards. Microphones are part of the package. Walkman type headphones provide private listening for individuals. Unamplified speakers may be part of the sound card package. The unamplified speakers are

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<sup>60</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242(6), v12 n4, April 1994.

<sup>61</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 26, Spring 1994.

<sup>62</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242(6), v12 n4, April 1994.

adequate for quiet rooms. In the noisy environment of a ship, magnetically shielded, amplified speakers will be needed to overcome the field affects of high frequency/high voltage equipment. Magnetically shielded, amplified speakers retail starting at \$200.00 per pair. The price increases with power and quality of the speakers.<sup>63 64</sup>

(9) *Multimedia Upgrade Kit.* Multimedia upgrade kits offer a packaged deal that contains the CD-ROM driver, cables, sound card, documentation and directions for installation, speakers, headphones and current software bundled into the package. Purchase of a kit ensures well matched components. There are numerous upgrade kits on the market. The requirements phase of the SDLC should provide the needed information when considering whether to purchase kit(s). Prices for kits start at \$300.00. Study the components carefully before purchasing any kit to ensure they meet the Command's criteria.<sup>65</sup>

(10) *Purchase of New System Off the Shelf.*

Purchase of a system in total, off the shelf, is the quickest way to upgrade to CD-ROM technology. The better manufacturers

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<sup>63</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 28, Spring 1994.

<sup>64</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242, v12 n4, April 1994.

<sup>65</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 31, Spring 1994.

now offer the option of including CD-ROM drives with the computer. The computers are prepackaged with the required hardware and software, ready for use straight from the package. When purchasing a computer system(s), the Command should check with the contracting officer to ensure it is staying within the regulation of the Defense Federal Acquisition Requirements (DFARS) for acquisition of information systems and not in violation of the Federal law.<sup>66 67</sup>

(11) *Building a CD-ROM System Yourself.*

Custom building a CD-ROM system is the most costly and time consuming option. It should not be attempted by someone who is not familiar with the architecture or workings of computer components. Computer components are static sensitive devices that can be easily damaged and should be handled carefully. When custom building a system there are a few guidelines to follow:<sup>68</sup>

1. Buy the best you can afford. Quality products will cost more but are more dependable and last longer if assembled correctly.

2. Look to the future. The requirements developed in the SDLC should account for future needs. Computer technology

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<sup>66</sup>Chen, S., "Making the Multimedia Upgrade", *Computer Shopper*, pg. 196(8), v14 n4, April 1994.

<sup>67</sup>Benford, T., "The 3 Paths to Multimedia Nirvana", *CD-ROM Today*, pg. 30, Spring 1994.

<sup>68</sup>Ibid, pg. 32.

changes rapidly and the custom computer should be built to accommodate anticipated changes. The motherboard is a good basis to start with. Purchase a motherboard that permits expansion and a power supply of 200 watts minimum.

3. Purchase the Best Peripherals. A custom built CD-ROM system with the best components will perform below expectation if run with mediocre peripherals. Choose a drive with the highest data transfer rate and lowest access time.

4. Shop for the Best. Decide which components you want for the system and shop for the best deal. Trade magazines and electronic supply warehouses would be a first stop.

## **6. System Design Phase**

### **a. Description**

In the design phase the Command will decide on how to meet the requirements from the definition phase. Traditionally the outputs are designed first because the output determines the design of the files on the CDs. Because the CDs are preformatted, software design is not a concern. Hardware configurations, however, will be a concern.<sup>69</sup>

### **b. Shipboard System Design Phase**

The shipboard design phase matches the components of the system. A concern with the hardware is the use of proprietary or nonproprietary components. If the command envisions a future of networking, it may be beneficial to start the basis of a network with components instead of purchasing stand alone systems that will require additional

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<sup>69</sup>Whitten, J. L., Bentley, L. D., and Barlow, V. M., *System Analysis & Design Methods*, 2nd ed., pg. 94, Irwin, 1989.



funding in the future.

The capability to print copies will be matched with the system. Laser printers, dot pin matrix, bubble jet, or ink spray printers are considerations. Placement of the printers will depend on the classification of the system itself at the discretion of the security officer.

The security of the system will have to be established. If the system is unclassified, then there is little concern. If the system is to be used for classified information, then security standards need development. The methods of security could be simple, such as giving the user a password, or complex for dealing with higher levels of security. Complex security involves a method of hierarchy where passwords and authorizations are needed to gain access to higher levels of information.

## **7. Construction Phase**

### **a. Description**

The construction phase is usually the most time consuming and involved phase. It is principally concerned with software development and hardware construction.

### **b. Shipboard Construction Phase**

The shipboard construction phase is the physical assembly of the system components. If a multimedia upgrade kit has been purchased, it is installed in this phase. If a CD-ROM system has been purchased with a computer, the computer

is connected to the other components. Interfacing of components is a concern in this phase.

Interfacing the CD-ROM drive with the CPU requires the decisions from the Study Phase to be realized. Use of proprietary drives offers little advantage over standardized drives and should be considered carefully. The majority of CD-ROM drives on the market use SCSI interfaces. A SCSI interface has important advantages over proprietary interfaces:

- The SCSI drive can be used on IBM compatible systems, Mac systems, and Sun workstations.
- SCSI is a standard interface. There is a wider selection of systems that are supported with SCSI interfaces that increases compatibility options for the command. Up to seven devices can be daisy chained (in series) without the use of a new interface card. This is an important point if the drive is external and intended for use on more than one system.
- The SCSI interface can be connected to a parallel port. This cannot be done with proprietary equipment.

## **8. New System Delivery Phase**

### **a. Description**

Delivery of the new CD system and placing it into operation stops the previous work environment. A smooth transition needs to be accomplished from the old system to the new system to help the end users cope with the new technology. There are four methods of transition from which to choose:

1. Parallel the System. The new system is used concurrently with the old system to ensure that no

information is lost in the conversion. This method is the safest but requires the most resources because it involves operating two systems simultaneously.

2. Phase-In. The old system is gradually phased out by area over time. This allows taking advantage of the new system while still being able to cope in the event of problems.

3. Direct Conversion. The conversion takes place all at one time. Major problems can occur if the new system has problems.

4. Area Conversion. The new system is implemented in only one area. The old system remains in the other areas until they are ready for cross over.

Which ever method is chosen, maintenance of a "Critical Incident" log will be beneficial in clearing bugs from the system. The conversion process also incorporates a training program and writing of user manuals to benefit the new users.<sup>70</sup>

#### ***b. Shipboard Delivery Phase***

The delivery of the system to the division or department involves educating the users on the system and placing the system in use. A training program should be started as soon as possible and incorporated into the annual training plan. Based on the survey results of Commanding Officers in the Atlantic Fleet, a Phase-In transition strategy is recommended (see analysis of Core Question 3, Chapter VI, Survey Results).

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<sup>70</sup>Ibid, pg. 94.

## **9. Maintenance and Improvement Phase**

### **a. Description**

Once a CD system is placed into service, using a conversion strategy, periodic reviews should be conducted for system hardware and software upgrades. The reviews keep the command current with problems, technology, and changes in users requirements.<sup>71</sup>

### **b. Shipboard Maintenance and Improvement Phase**

Maintenance and improvement of the shipboard system should consider periodic cleaning of the components and drives, visual inspections for damaged or loose connectors, and a periodic reevaluation on possible upgrades to be made.

Whenever a system is placed into operation, the system may not perform correctly. A few of the more common areas to look at are given.

#### *(1) Troubleshooting Multimedia Kits*

Installation of components or kits will take time. Allow for adequate time. Install the components or kit(s) in accordance with the manufacturer's directions. Some common problems to watch for are: <sup>72</sup>

- Device Conflicts. If after installation the system gives a "Can't find the sound board or CD-ROM" response, check to ensure there isn't another ISA card using the same

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<sup>71</sup>Ibid, pg. 95.

<sup>72</sup>Chen, S., "Making the Multimedia Upgrade", *Computer Shopper*, pg. 196(8), v14 n4, April 1994.

memory address, interrupt request line, or DMA channel. Installation software can only tell you of hardware conflicts, the user must make the corrections manually. Use of MEM or MSD commands from the DOS directory can inform you which of the system resources are allocated to what device. As a last resort, remove all ISA cards before installation and reinstall them after the kit is installed.

- No Audio. Check to ensure the power supply, data, and audio cables are seated correctly and the data cable between the sound card and CD-ROM drive is seated with Pin 1 aligned between the cable and the two connectors. Check that the audio cable between the CD-ROM drive and the sound board is connected. Lastly, verify the speakers are connected to the output and not the input jack of the sound board.
- Can't Play an Audio CD. The Windows' audio driver may not be installed. Use the control panel to add the driver. After installation, reboot so that the driver changes are recognized.
- Volume is Too loud or Too Soft. Rotate the volume control on the sound board to halfway between the minimum and maximum settings for the volume. This ensures some output is occurring. Enter the DOS or Windows mixer utility to raise the volume levels for the CD-audio. If volume is still low, adjust the control to maximum gain.
- No audio in recording. Set the Play/Record button to Record, not Play.
- Memory Problems with DOS Applications. CD-ROM drivers are loaded automatically when the system boots. The driver may affect the system conventional memory. If this occurs, create an edited version of the AUTOEXEC.BAT and CONFIG.SYS files with the references to CD-ROM and sound card drivers disabled. Create a batch file that swaps normal and edited configuration files to the root directory.

## *(2) Sound Card and Compact Disk Driver Interface*

The installation of the sound card with the CD-ROM drive is critical for successful operation of the CD-ROM system. Sound cards are major users of computer resources

and they compete with other peripherals for the resources. Smooth installation entails monitoring the peripheral equipment for proper operation. If the system is experiencing problems, there are hints to help in trouble shooting the system.

- Identify the CD-ROM interface on the sound card. Some sound cards use a SCSI interface while others are proprietary. If the sound card has no CD-ROM interface, then a SCSI adapter must be purchased for the CD-ROM unit. If the computer presently has a sound card with a SCSI adapter installed then purchase a CD-ROM that supports SCSI and add the CD drive to the daisy chain.
- Keep track of all peripheral devices in use and log the devices. This is a preventative measure, regardless of the type of bus (ISA, EISA, or Local Bus). PC's have 16 IRQs, nine of which are free for peripheral usage.
- Be careful when using IRQs 2 and 9 because the two are linked internally. The IRQs are the hardware line used to send service requests to the CPU. If IRQ 2 is in use by another device, then do not use IRQ 9. If IRQ 9 is in use, then do not use IRQ 2. The two are linked through ISA engineering design. Originally the XT bus had 8 IRQs. To increase the number, a cascade controller was installed on the motherboard. The cascade controller uses IRQs 2 and 9 to link the lower eight and the upper eight IRQs. If both IRQs are using peripheral devices, then conflicts occur. See Table I for typical IRQ allocation.
- Pay attention to the number of pins on the interfaces. Make sure the pins match for both the male and female connections. Some SCSI adapters have plastic frames around them with a guide slot to ensure correct matching. If an adapter is missing the guide, do not use it. Pin 1 on the cable must match the SCSI interface on the sound board interface. Pin 1 is usually red or blue and located in the upper left corner of the cord. Incorrect wiring will damage the SCSI cable, the host adapter and the SCSI device (CD-ROM drive) which is being attached to the host.
- Use the right cable. There are presently over 600 combinations of cables for CD-ROM drive to soundboard connections. Finding the correct cable can be difficult. Multimedia upgrade kits provide the proper cable. Sound

board vendors may not be able to provide you with the needed cable. There are companies that specialize in providing unique cabling, such as CD-ROM Access (1-800-959-5260) and TTS Multimedia Cables (1-800-887-4968). Identify the soundboard prior to contacting the vendor and they can find the proper match.

**Table I** IRQ USAGE

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| IRQ | USAGE                  |
|-----|------------------------|
| 0   | System Timer           |
| 1   | Keyboard               |
| 2   | Cascade from IRQ 9     |
| 3   | COM3, COM4             |
| 4   | COM1, COM3             |
| 5   | LPT2                   |
| 6   | Floppy Disk Controller |
| 7   | LPT1                   |
| 8   | CMOS Clock             |
| 9   | Redirect to IRQ 2      |
| 10  | Free                   |
| 11  | Free                   |
| 12  | Free                   |
| 13  | Math Coprocessor       |
| 14  | Hard disk controller   |
| 15  | Free                   |

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Use caution when installing a sound card and the CD-ROM driver to avoid complications.<sup>73</sup>

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<sup>73</sup>Salvatore, D. and Moran, J., "Sound Cards and CD-ROM Drives", Window Sources, pg. 188, v2 n5, May 1994.

## **E. THE NEAR FUTURE OF COMPACT DISK**

### **1. Plug and Play (PNP)**

CD-ROM systems have a system weakness due to the ISA architecture. Users installing CD-ROM systems, presently have to configure each new sound card and video board manually to avoid device conflicts. This is due to the ISA bus which doesn't allow for automatic configuration of the cards. Users must manually adjust DIP switches to allocate IRQs, memory addresses and DMA channels. The weakness is being corrected with the Plug-N-Play (PNP) specification. In the future, installation will be a matter of plugging in the new card and loading a device driver. The plug in will either be into the mother board with an extra connector or plug into extensions on a hard drive's IDE cables. With the introduction of the PNP system, it is predicted the number of SCSI drivers sold will decline because of the predicted cost savings with the PNP which outweighs the technological advantage of the SCSI drives.<sup>74 75</sup>

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<sup>74</sup>Chen, S., "Making the Multimedia Upgrade", *Computer Shopper*, pg. 196(8), v14 n4, April 1994.

<sup>75</sup>Hamilton, A., "CD-ROM drives and sound cards. (Multimedia Special Report)", *PC World*, pg. 242, v12 n4, April 1994.



## **2. Compact Disk-Erasable (CD-E)**

CD-E is a technology based on phase change recording instead of the present Magnetic Optical (MO) because CD readers operate in changes of reflectivity to read data. The technology bases itself on the phase changes of certain compounds after being exposed to laser energy. Reading a disk is accomplished using a lower intensity beam. A higher energy beam is used to alter the disk for data storage. The success of a CD-E system will depend on the technology being able to utilize the current CD-ROMs in service. The best option is a multi-function platform that can read CD-ROM or CD-R and still be a replicating system.<sup>76</sup>

### **F. ECONOMIC ANALYSIS OF A COMPACT DISK SYSTEM**

The economic analysis of a CD system involves an evaluation of alternative CD systems with regards to their cost, benefits, and uncertainties. The economic analysis does not necessarily result in the purchase of the cheapest system. There are 2 basic premise for economic analysis of a shipboard CD system:<sup>77</sup>

1. Investigation of all reasonable alternatives.

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<sup>76</sup>Ferelli, M., "CD-What? The Next Step in CD Storage", Computer Technology Review, pp. 36-38, Vol XIV, N8, August 1994.

<sup>77</sup>Haga, W. J. and Lang, R. G., *Revised Economic Analysis Procedures for ADP*, Master's Thesis, Naval Postgraduate School, Monterey, California, January 1991.

2. Consideration of the absolute value of the current and future expenditures of the CD system and the alternatives.

## **G. USE OF ECONOMIC ANALYSIS**

Economic analysis is used in two ways: First to assess the economic impact of future decisions, assuming a decision is made based on the alternatives. Second, to assess the economic impact of past decisions, assuming a decision has been made, to influence future decisions.

### **1. Scope of Economic Analysis**

The economic analysis of a CD system is limited in its scope. It does not establish Command priorities from the goals and requirements of the SDLC. Its purpose is to find the most cost effective means of establishing a CD system. The analysis is an input into the decision process and not a final judgement. The value of the analysis is only as good as the information used as input and the element of uncertainty can never be eliminated. The Command should weigh each result carefully against other factors that have been established in the SDLC. An economic analysis can become intensive and may not be cost effective in some cases where the cost of the manpower involved exceeds the costs for the CD system.<sup>78</sup>

### **2. Economic Analysis Process**

The economic analysis is a six step, systematic process for comparison of alternatives in order to satisfy the

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<sup>78</sup>Ibid.

requirements of the SDLC. The results should be documented for future reference describing the steps taken to identify the criteria, the scope of the analysis, the Command's methodology, and the conclusions and recommendations of the process.

**a. The Objective**

The first step in the analysis is defining the main objective, the primary standard for accomplishment. the task is to state the objective as a mission, worded carefully to reflect an unbiased point of view concerning the methodology to use in solving the problem.<sup>79</sup> An example of an objective would be to install a double speed CD-ROM system in the Operations department. The system will exceed MPC 2 standards, use a 486DX2/66mhz computer with 32MB RAM, a 1GByte hard drive, and use a SCSI interface.

**b. Assumptions**

The second step is the formulation of assumptions. Assumptions can be explicit statements describing the present and future conditions for the shipboard CD system. The purpose of an assumption is to limit the analysis of the CD systems and to make the investigation of alternatives more manageable. The assumption can be written as a restriction. The use of OPNAV INST 5230 restrictions as a starting point can be incorporated into the Commands own restrictions. When

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<sup>79</sup>Ibid.

making assumptions, follow simple guidelines:

- Assumptions are not facts. Assumptions are used to fill in for information that is unattainable after searching.
- Make the assumptions realistic.
- State the assumptions positively.
- Determine if the conclusion is still valid without the assumption. If it is, then eliminate the assumption because it is not a requirement that needs to be met.

When making assumptions, constraints are to be considered. A constraint is an external factor that limits the alternatives to the solution. The external constraint is beyond reasonable control and they provide boundary limits for the alternative solutions to the problem. The interim guidance for destruction of CDs is a constraint.<sup>80</sup> The International Standards Organization (ISO) Standard 9660 is a constraint. The Command assumes that the format of the CD is standardized

### ***c. Choosing Alternatives***

Identification of all feasible methods to meet the objective(s) to produce a CD-ROM system is the third step. An indepth study of characteristics for various CD-ROM systems will be required. The same requirements developed in the SDLC are applied universally to each system deemed an alternative. When determining alternatives avoid needless constraints. Needless constraints can exclude superior alternatives. The

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<sup>80</sup>Ibid.

minimum requirements must be met for the CD-ROM system to be acceptable as an alternative. The final evaluation and selection of the CD-ROM system is to be completed later. Selection of alternatives according to costs for a CD-ROM system in order of preference are:

- Modifying a current system
- Requisitioning new PC systems with CD-ROM capabilities through the Navy supply system.
- Contracting with civilian contractors for PC systems with CD-ROM capabilities.
- Custom made PCs with CD-ROM capabilities.

Each method has various solutions. The Command will have to decide which alternative best fits their needs.<sup>81</sup>

***d. Determination and Relation of Costs and Benefits***

Estimation of the costs and benefits of individual CD-ROM systems may be the most time consuming process. Year by year estimates will have to be made for costs. Benefits should be quantified whenever possible, for example: faster access time, better storage capabilities, or smaller unit dimensions. The acceptance of the analysis will depend on the reliability of the estimates. All cost and benefit data should be documented for future reference.<sup>82</sup>

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<sup>81</sup>Ibid.

<sup>82</sup>Ibid.

**e. Comparison of Alternatives**

When the cost and benefits are calculated for each alternative CD-ROM system, each system can then be compared to each other. Comparison of alternatives begins with three general criteria:

1. The least cost for a given performance of a CD-ROM system.
2. The most effective CD-ROM system for the cost.
3. The most effective CD-ROM system for a given constraint.

The comparison of alternatives can be summarized in Table II.

**Table II** COMPARISON OF ALTERNATIVES

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| <u>COSTS</u> | <u>COMPONENTS</u> | <u>RECOMMENDATIONS</u>        |
|--------------|-------------------|-------------------------------|
| Same         | Various           | Most components (Note 1)      |
| Various      | Same              | Least cost (Note 2)           |
| Various      | Various           | Most components to cost ratio |
| Same         | Same              | No analysis is needed         |

Note 1: If alternatives have same costs but various components, the alternative with the largest number of components will have the greatest benefit to cost ratio.

Note 2: If all alternatives have similar components, the least cost alternative will have the greatest benefit to cost ratio.

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## ***f. Sensitivity Analysis***

The amount of uncertainty in the economic analysis should be examined to determine the level of influence of the recommendation. Determine how results may change with changes in the CD-ROM system parameters or core assumptions. If a change in a parameter or core assumption results in a major change in the analysis, then the analysis is sensitive to that parameter or assumption.<sup>83</sup>

### **3. Costs Estimation**

Cost estimation relates the requirements of the CD-ROM system to specific costs.

(1) *Industrial Engineering.* For large projects, the Industrial Engineering methodology can be used. Industrial Engineering is a consolidation of the various work package estimates into a single, detailed, summated estimate.<sup>84</sup>

(2) *Parametric Estimation.* When the CD-ROM project is not large, the use of Parametric Estimation is reasonable. The parametric estimate focuses the estimate based on requirements and costs.<sup>85</sup>

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<sup>83</sup>Ibid.

<sup>84</sup>Ibid.

<sup>85</sup>Ibid.

(3) *Analogy Method.* The Analogy method is used when no qualified cost analysts and little historical information is available. Analogy uses direct comparison of costs of alternatives with the benefits involved and is the most common methodology in use. However, it is not the most accurate.<sup>86</sup>

(4) *Delphi Method.* The Delphi Method uses an experts opinion to get an estimate. The Delphi method is a long and cumbersome process because of the questioning and feedback process used to arrive at a decision that is influenced by the experts opinions. It is not a realistic alternative for an afloat Command.<sup>87</sup>

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<sup>86</sup>Ibid.

<sup>87</sup>Ibid.



#### **IV. MANAGEMENT CONCERNS**

##### **1. Mangement Concerns**

Implementing and managing a new technology requires an understanding of how changes are viewed, how they are reacted to, and how to manage the reaction to lessen any resistance.

##### **2. Psychology of the Resistance to Change**

Change involves a psychological process that requires strengthening the views of the crew towards the system to reduce the amount of resistance that may be encountered. There are several factors that may affect how a crewmember might view the change:

- Basic predisposition to change.
- Personal sense of security.
- Prevailing cultural beliefs.
- The extent of trust and loyalty among peers.
- Effects of past changes.
- Individual apprehensions and expectations of the system.

Each individual is unique and predicting the change is difficult especially with those affected.<sup>88</sup> Monitoring the crewmembers parallels the implementation process of the new

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<sup>88</sup>Bryant, D., "The Psychology of Resistance to Change", pp. 9-10, Management Services, March 1979.

technology, which should be monitored for:<sup>89</sup>

- Pace: How long will it take for the change to take place when installing a CD-ROM system?
- Scope. Should the change start in a small division or implemented shipwide? If the change implementation is to be shipwide, the impact of the change may not be absorbed.
- Supporting Structures. What types of support does the Command currently have for the CD-ROM system? The implementation should be seen as having total support from the Commanding Officer down.

### **3. Reacting to Change**

In a command the implementation of a new technology rarely considers the reactions of the crew. Typically there is a resistance to change. If the resistance is not anticipated and managed, the implementation of the system can be difficult or unsuccessful.

A distinctive resistance is the inertia to prevent a change due to habits previously formed, the maintaining of the status quo. The habits that are ingrained into a crew are a form of control. When a change takes place, there is an initial confusion until a routine or familiarization can occur. The confusion can result in a loss of control in the surroundings. A person with years of experience, who has worked with manuals, is quite familiar with the pages. When faced with the implementation of manuals onto a new media such

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<sup>89</sup>Jick, T., "NOTE; THE CHALLENGE OF CHANGE", Harvard Business School, pp. 3-6, Serial Number 9-490-016, 19 June 1990.

as CDs, the person is not familiar with the format. They have a sense of losing control and respect from their peers and the crew. The further removed a person is from the reasons for the change in the operations of the system, the more threatened they may feel.<sup>90</sup>

Use of a paperless system will involve people becoming committed to an idea. A trust must be developed by the users, and this trust should be seen as originating from the Commanding Officer. To gain the commitment needed the Command should implement an educational and training program to include meetings on the progress of the systems development. Transforming the Command may be frustrating. Paper copies of manuals will still be found onboard ships even though the complete set is in the CD-ROM library. Transitioning from the manuals can be seen as a loss of confidence by the crewmember. To encourage the use of the CD-ROM system, the command should reorient the perceptions throughout the Command with an aggressive training program. The person who experiences the feeling of loss can adapt faster if there is a legitimate outlet for them to vocalize their concerns and rationalize the changes for themselves.<sup>91</sup>

When implementing a change to any organization, there are

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<sup>90</sup>Ibid, pg. 7.

<sup>91</sup>Beer, M., "Leading Change", Harvard Business School, pp. 4-7, Serial Number 9-488-037, 1988.

some underlying assumptions that should be understood:<sup>92</sup>

- A change involves learning something new and unlearning a previous method that may be well ingrained into the command structure.
- No change can occur without motivation. If there is no motivation present, the change can be difficult.
- Adult changes involve attitudes, values and self-images. Responses to these changes can be viewed as threatening.
- Change is a multistage cycle.

When implementing the CD-ROM system, view it as being in three stages; unfreezing, changing, and refreezing.

**a. Stage 1: Unfreezing-Creating Motivation for Change**

Creation of motivation for change can be complex and may involve three separate mechanisms that work concurrently for an individual to feel motivated about the change and unlearn present behaviors or attitudes.<sup>93</sup>

(1) *Mechanism 1.* The present attitudes should be reoriented over a period of time or even made difficult. Referring to a tech manual should be discouraged and use of the CD-ROM system should be made easy. If there is no discomfort with the old methodology there will be no motivation for the change to occur.

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<sup>92</sup>Schein, E., *Organizational Psychology*, 3d ed., pg. 243, Prentice Hall Inc., 1980.

<sup>93</sup>Ibid, pp. 243-244.

(2) *Mechanism 2.* The discomfort must be sufficient to motivate the change.

(3) *Mechanism 3.* A safety atmosphere should be created to remove barriers to the change. Crewmembers must view the change as reducing burdens rather than increasing the current work load, particularly in a downsizing military. Crewmembers must be made interested in the technology and view it as a tool to become more efficient. The autonomy and security of the individuals must not be threatened. Individuals must not be intimidated by the technology and should be encouraged to use it. The system should be acknowledged by the crewmembers as improving the managability of documents. The crew should feel comfortable in using the system without reducing the discomfort of Mechanism 2. Reassurance should be given to crewmembers to help in building the safe atmosphere.<sup>94</sup>

***b. Stage 2: Changing-Development of New Attitudes***

Creating the motivation needed for change involves showing the crewmember new ways of looking at old methods, a cognitive redefinition. The storage of material onto CDs to reduce excess weight and save space redefines the manner in which information is stored.

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<sup>94</sup>Bryant, D., "The Psychology of Resistance to Change", pp. 9-10, Management Services, March 1979.

(1) *Mechanism 1.* Identification with a role model or friend allows one to learn to view ideas from the another perspective. Use of peers in the Command builds confidence among the crew for the acceptance of the new technology and helps in the development of new attitudes.

(2) *Mechanism 2.* Scanning is useful to determine what is relevent from the individuals point of view. Allowing a crewmember to view a system in use by others allows the crewmember to remain in control and glean what they deem as relevant.

***c. Stage 3: Re-Freezing-Stabilizing the Change***

A reoccurring problem of attitudinal change is continuity. Once a person has completed training and is back in a normal routine, what was previously learned does not fit into the present environment or is not viewed as important by crewmembers. People higher in the chain of command may not be comfortable with the new technology and they discomfirm the new attitude of the crewmember, changing the views of the newly trained crewmember back to the previous state, maintaining a status quo. Ensuring stability requires attention to integration of the new attitudes among the crewmembers.<sup>95</sup>

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<sup>95</sup>Schein, E., *Organizational Psychology*, 3d ed., pp. 244-246, Prentice Hall Inc., 1980.

(1) *Mechanism 1.* New attitudes need to be tested for acceptance.

(2) *Mechanism 2.* A crewmember should be allowed to confirm the new attitudes of the system with other crewmembers who will reinforce the new behaviors in each other.

## V. THE SURVEY

### A. OBJECTIVE

The objective of the survey was to determine the extent of CD-ROM usage in the Atlantic Fleet surface forces and the major concerns commanding officers have about the technology. The information will be forwarded to Commander, Naval Surface Forces Atlantic (CNSL), Office N611. The information will provide a basis to start studies into the commanding officers' concerns and the implementation of CD-ROM technology into the areas viewed as needing it the most by the end users, the commanding officers.

### B. RESEARCH QUESTIONS

To meet the objectives of the research a set of "Core Questions" was developed with CNSL N611. The "Core Questions" and their motivation are given below:

- Core Question 1: What ships currently have CD-ROM installed, how many, and in which departments?
- Motivation: The investigation must know in which commands CD-ROM is installed for future reference and may ease the financial burden if a possible networking pilot program can be established.
- Core Question 2: How often are the CD-ROM system(s) utilized and has there been any training for the system?
- Motivation: End users utilize a system more readily if



- they are comfortable with the technology. If training is absent, then the end users may not be comfortable with the technology and a more aggressive training program may need to be developed.
- Core Question 3: In what order would the commanding officers prefer their departments converted to CD-ROM technology?
  - Motivation: User feedback is critical when developing and implementing systems. Commanding officers know in which departments the paper burden is the greatest and where the CD-ROM technology can have the fastest impact to gain crewmember support.
  - Core Question 4: What concerns do the commanding officers have about CD-ROM technology.
  - Motivation: Determining the concerns of a new system from the end user helps in development of programs to alleviate the concerns and the establishment of training programs which aid in the transition and use of the new system.
  - Core Question 5: If a pilot program for installation and conversion to CD-ROM technology can be funded, would the command be willing to participate.
  - Motivation: A pilot program may have a greater chance of success when it is more readily accepted.

### **C. METHODOLOGY**

From the core questions a survey was developed (Appendix A). Some of the "Core Questions" were asked directly, while others required several questions. The survey questionnaire was developed to be answered quickly in a minimal amount of time. All the questions were formatted for selection from a list, ten of the survey questions allowed an additional write in response if the respondent felt it necessary.

Feedback on the survey was solicited from CNSL, N611. Their suggestions were incorporated into the survey. CNSL was

included into the survey to provide reassurance and validity to the commanding officers concerning the survey.

#### **D. SCOPE**

The choice of the Surface Forces of the Atlantic Fleet for the survey was based on two premises:

- The Commander, Surface Forces Atlantic, is a Naval Postgraduate School alumni with a degree in Computer Science Management.
- The authors familiarity with the Atlantic Fleet.

The survey attempted to concentrate on those ships commissioned prior to 1992 and not scheduled for decommissioning within the next four years. Because of the downsizing efforts of the Department of the Navy it was not feasible to discern every ship scheduled for decommissioning prior to mailing of the surveys.

The survey was mailed out as a blanket survey to the Surface Forces of the Atlantic Fleet. 116 surveys were mailed, seven surveys were returned as undeliverable due to decommissionings. From the 109 surveys delivered, 61 commands responded for a response rate of 55.9%.

## VI. SURVEY ANALYSIS

### A. CORE QUESTION 1

Core Question 1 was: "What ships currently have CD-ROM installed, how many, in which departments and how did the Commands get the CD-ROM systems?". It took five survey questions to answer the core question. The responses were tabulated to reflect the respective response of the respondents (Appendix B).

#### 1. Organization of Data

Question 1 was used to separate the respondents by ship type. Surveys were mailed to every class of ship indicated in Question 1. Question 2 isolated those commands with CD-ROM technology and those commands without the CD-ROM technology. Question 3 determined the extent of CD-ROMs onboard a vessel and question 4 determined in which areas the CD-ROMs are being used. Question 5 determined from where the CD-ROM systems came from. Questions 1 through 5 are listed below:

Question 1. Please indicate your ship type.

|          |          |          |          |          |            |
|----------|----------|----------|----------|----------|------------|
| ___AE21  | ___AE26  | ___AO177 | ___AOE1  | ___AOR1  | ___CG47    |
| ___DDG51 | ___DD963 | ___DD994 | ___FFG7  | ___LCC   | ___LHA1    |
| ___LHD1  | ___LPH2  | ___LPD4  | ___LSD36 | ___LSD41 | ___LST1179 |
| ___MCM   | ___MSO   | ___Other |          |          |            |

- Question 2. Do you currently have a CD ROM system installed on your ship?  
☐ Yes ☐ No (Please go to question 8)
- Question 3. How many CD systems do you currently have on your ship?  
☐1 ☐2 ☐3 ☐4 ☐5 ☐More than 5 (how many ☐)
- Question 4. In which departments do you have CD systems? (Check all that apply)  
☐Combat Systems ☐Deck ☐Engineering ☐Operations  
☐Supply ☐3M ☐Navigation/Administration ☐Other
- Question 5. How did you obtain the CD systems?  
☐Purchased with own funds ☐Issued by SURFLANT  
☐Other\_\_\_\_\_

Checking a blank indicated a yes/no answer which was tabulated. Questions 1 and 3 are represented by Tables 1 and 2, Appendix B, respectively. Question 4 is represented by Pie Chart 1, Appendix B, and Question 5 is represented by Chart 2, Appendix B.

## 2. Analysis of Data

With the exception of the DDG 51 class, every ship type surveyed provided at least one response and there was surprisingly, varied ranges of the number of CD-ROM systems installed. Only two commands (3.3%) did not have CD-ROM systems onboard, therefore Question 2 is not plotted. The biggest surprise was to find respondent number 40, an AEGIS cruiser, without any CD-ROM technology onboard. This command will require the purchase or issue of at least one CD-ROM system in order to stay current with OPNAV INST 5230.

The distribution of CD-ROMs throughout the respondents' departments are relatively balanced. The systems are predominately in use in the following departments: Supply(18.5%), Engineering (17.1%), and Operations(16.4%). Other areas of use are: Medical, Educational Services Office (ESO), Air Intermediate Aviation Department (AIMD), Communications, Air, and Damage Control.

## **B. CORE QUESTION 2**

Core Question 2 was: "How often are the CD-ROM systems utilized and has there been any training for the system?" The core question attempts to address the issue of training and the amount of usage the CD-ROM systems are experiencing. Questions 6 and 7 were used to gather the information.

### **1. Organization of Data**

The questions were presented in a yes/no format with the option of writing in additional information. Questions 6 and 7 are listed below:

- Question 6. On a daily basis, indicate how many individual hours your crew uses a CD system?  
\_\_\_1-2 Hours \_\_\_2-4 Hours \_\_\_4-6 Hours \_\_\_>6 hours  
\_\_\_Not used daily
- Question 7. How many hours of formal training have been conducted in the use, management, and maintenance of your CD system(s)?  
\_\_\_1-4 Hours \_\_\_4-8 Hours \_\_\_1-2 days  
\_\_\_No formal training \_\_\_Other

Questions 6 and 7 are tabulated in Table 3, Appendix B,

and Chart 3, Appendix B, respectively.

## **2. Analysis of Data**

Four respondents (6.6%) did not provide answers to question 6. Two respondents (3.3%) were not applicable because they did not have CD-ROM systems onboard. Three respondents (4.9%) indicated they did not use their system daily. Seven respondents (11.5%) were uncertain of their usage. The majority of the respondents used their CD-ROM systems daily. Fifteen respondents (24.6%) used their systems at least 1 to 2 hours daily. Nine respondents (14.8%) used their system 2 to 4 hours daily, eleven respondents (18.0%) used their system for 4 to 6 hours daily and nine respondents (14.8%) reported using their systems more than 6 hours daily.

The extensive usage may indicate the Commands are comfortable with the CD systems and that they have been easily assimilated into the command structure despite the lack of formal training indicated in Chart 3, Appendix B.

The "Other" responses to the training question were not filled in by the 2 respondents indicating that an alternative training methodology was conducted.

The lack of formal training indicated (55.7%) in Chart 3, Appendix B, is surprising. The majority of the training conducted is in a 1 to 4 hour time frame which may indicate the level of future training programs for similar systems. Attempts to stay within this time frame are recommended.

When the ships transition to integrated networks for CD-ROMs, a formal training program should be developed for maintenance and usability.

### C. CORE QUESTION 3

Core Question 3 was: "In what order would the commanding officers prefer their departments converted to CD-ROM technology?" Core Question 3 was a direct question to the end users asking them to rate the departments in order of preference for conversion to CD-ROM technology and the difficulty in the conversion.

#### 1. Organization of Data

Question 8 and Question 11 were used to answer Core Question 3. Question 8 was used to rank the departments for the end users choice of conversion to CD-ROM technology. Question 11 was used to rate the difficulty of implementing the CD-ROM technology. Questions 8 and 11 are listed below:

- Question 8. The Navy is currently working towards "paperless" ships. Please rank the departments (first to last) where you would convert the documentation for a CD system.  
\_\_\_ Combat Systems \_\_\_ Deck \_\_\_ Engineering \_\_\_ Operations  
\_\_\_ Supply \_\_\_ 3M \_\_\_ Navigation/Administration  
\_\_\_ Other \_\_\_\_\_
- Question 11. Please indicate the difficulty in converting your departments to CD technology, a '1' being the easiest and a '5' being the hardest.  
\_\_\_ Combat Systems \_\_\_ Deck \_\_\_ Engineering  
\_\_\_ Operations \_\_\_ Supply \_\_\_ 3M \_\_\_ Navigation/Administration

Question 8 responses are tabulated in Tables 4a through 4h, Appendix B, respectively. Question 8 "Other" responses had two respondents (3.3%), which did not require plotting. Question 11 responses are tabulated in Tables 5a through 5g, Appendix B, respectively.

## **2. Analysis of Data**

The predominate conversion trends of the commanding officers indicate the Supply Department should be converted to CD technology first. The 3M area should be converted second and the Combat Systems Department converted third. The fourth conversion is recommended to be Engineering. The Operations departmental conversion should be fifth followed by the Nav/Admin and Deck area converted sixth and seventh respectively. Prior to any conversion, the respondent outlayers should be interviewed to understand why they answered out of the majority. Those respondents may have a specific insight which may not be seen by the majority of respondents and will only become apparent after the conversion is in process.

Two opposing views can be taken on the implementation strategy:

1. Supply and 3M are paper intensive areas that require extensive cataloging of information. The information does not change readily and changes can be handled with an advanced change notice, to be kept on file until updates are economically feasible.

2. Supply and 3M may not be viewed as mission critical



areas. If a system is installed in an area and it fails, either during or after implementation, the command can still perform its core mission. The lessons learned from implementing the two areas can then be applied to mission critical areas for smoother implementation.

The first view holds more credence because the areas of Deck and Navigation/Administration can each be paper intensive and non-critical. If the second view was true, then the last two areas would have been placed prior to Operations, Combat Systems, and Engineering Department.

Cross comparison of Question 8 and Question 11 indicates the conversion of the Supply Department, the 3M area, and Combat Systems Department to be "easy" by the Commanding Officers' inputs. The lessons learned in their conversion may help in the fourth preference conversion of the Engineering Department which the Commanding Officers indicate as encountering possible minor difficulty. Operations and Nav/Admin are indicated as easy to convert after the Engineering Department. Deck conversion, being last, also has little difficulty.

#### **D. CORE QUESTION 4**

Core Question 4 was: "What concerns do the Commanding Officers have about CD-ROM technology?" The question is an attempt to discover the concerns of Commanding Officers so the issues may be resolved.

## 1. Organization of Data

Core question 4 was a direct question to the respondents using survey Question 12. The question was formatted in a list of yes/no responses with the option of writing in additional responses. Question 12 is listed below:

Question 12. What concerns do you have concerning CD technology. Please check all that apply.

☐ No phase replacement for older systems

☐ Security violations      ☐ Hidden costs

☐ Lack of technical support      ☐ No management criteria

☐ Loss of future funding      ☐ Too costly to maintain

☐ CD technology will be surpassed      ☐ Other\_\_\_\_\_

Question 12 is tabulated in Chart 4, Appendix B.

## 2. Analysis of Data

The Commanding Officers indicated Technical Support (23.3%) and Phase Replacement (18.5%) as primary concerns for CD-ROM system. Funding (12.3%), Management Criteria (11.6%) and Hidden Costs (11.6%) were secondary concerns. Maintenance costs (2.7%), Security (8.9%), and Outdated Technology (7.5%), appear to be minor concerns.

The primary and secondary concerns of the Commanding Officers are a vicious circle. Technical support is the number one concern of the Commanding Officers. To have confidence in their systems, the Commanding Officers must feel it can be repaired quickly if a problem develops. To do this

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the command needs: capable crewmembers, parts, and money. Crewmembers will require new training on computer diagnostics and repairs. The most capable rate is the Electronic Technicians (ET). Placement of senior, experienced Data Processing (DP) personnel as managers of a system compliments the ET training. This will require changing a ship's manning requirement. Parts can be purchased as COTS items at competitive prices. The supply department can adjust inventories to include additional items for computer spare parts based on demands of specific part failures.

Funding is a crucial issue that is dependent upon each command and should be budgeted for in the overall submission of the ship's annual budget strategy. There is no magical percentage to look at. The command should consider the areas in need of expansion then budget for the estimated amount needed in the expansion. Phase replacement of the technology is driven by funding. When to replace the equipment is an independent decision. Replacing the hardware and software annually is financially inconceivable but a cost benefit analysis on specific products can be conducted and decisions reached. The computer industry changes rapidly and the command should keep abreast of developments in trade magazines to be informed.

Management criteria for the Navy needs development. There are numerous strategies, texts, and courses currently available to lay a foundation for sound management. Each

command will have to develop its own strategy independently. Utilization of the Naval Postgraduate School's Systems Management Department for Information Technology Management would be a wise starting point and a sound financial investment.

Other concerns (7.5%) written in by the Commanding Officers are:

- Handling of CD systems.
- ADP Regulations.
- CDs are not updated quickly enough.
- People are not comfortable with the technology and have neither the time nor the inclination to learn.
- Not having write capabilities.
- Destruction of CDs.
- No standard CD access program.
- Print quality.
- Lack of repair parts.
- Distribution of CD-ROM software and availability of software.
- User interface (friendly software interface).
- Output (hard copy) capabilities.

The low response to maintenance costs (2.7%) is a misleading concern. Maintenance costs of information systems (which include CD-ROM) increase with the age of the system. The increases should be planned and budgeted for in the commands annual budget submissions for funding.

The handling of CD systems and ADP regulations will become a concern for Commanding Officers in the future. Commanding Officers and Contracting Officers may want to become familiar with:

- Government Services Administration (GSA): Overview Guide on Acquisition of Information Resources, January 1990.
- DOD Instruction 8120.2: Automated Information Systems (AIS) Life Cycle Management (LCM) Process, Review and Milestone Approval Procedures, 14 January 1993.
- DOD Directive 8120.1: Life Cycle Management (LCM) of Automated Information Systems (AISs), 14 January 1993.

The publications are guidelines for major acquisitions, but their principles are applicable to smaller scale AIS acquisitions.

The updating of CDs and their availability is a cost issue that needs to be reconciled. Updating of current material will occur more frequently as Commands install more CD systems and request material on CDs vice printed material. User interface with the CD software is a classic design issue that can only be corrected by user and design engineer interface prior to the software development. User inputs are a critical factor in friendly interfaces. The inputs prevent resistance to the software and avoids costly redesigns in the software in later stages. Given the current trend of purchasing commercial items off the shelf (COTS) to reduce costs, familiarity with trade magazines that review software and hardware can enable a Command to make better informed

decisions in the purchase of software and hardware that is more user friendly and have beneficial attributes.

Hardcopy capability is a design issue that should be addressed in the user requirements stage. It is also a security issue when the system will be used with classified material. The ability to randomly print classified material will create an enormous burden on the security officer.

Write capability is a technology issue. As the technology becomes more familiar to the general public the write technology will replace the current floppy disk where the user is not burdened with the complexity of formatting and layout of the disk. Write capabilities do exist for those that want to expand into the area, but with everything else in information technology, as new items come to market, prices eventually drop. In the next three years a significant gain in CD-R and Compact Disk-Erasable (CD-E) should occur. The CD-E format parallels the current floppy technology of writing and erasure of files to a disk numerous times.

Disk destruction is a security and environmental issue. Until the National Security Agency (NSA) and the Environmental Protection Agency (EPA) develop proper standards for destruction and disposal, the disks will remain onboard, an expanding issue for the Commanding Officers.

Lack of repair parts can be relieved through purchases in the civilian market. The supply and demand of computer hardware and software in the competitive market ensures

current up-to-date material is available at competitive prices.

#### **E. CORE QUESTION 5**

Core Question 5 was: "If a pilot program for installation and conversion to CD-ROM technology can be funded, would the command be willing to participate". Several survey questions were to answer Core Question 5.

##### **1. Organization of Data**

The questions were formatted in a yes/no response and easy identification. Questions 9, 10, and 13 are listed below:

- Question 9. When would you prefer to install a CD system in a department?  
\_\_\_Major overhaul period\_\_\_Intermediate availability  
\_\_\_Other, please specify when\_\_\_\_\_
- Question 10. Would you prefer to use one department as a test site to determine the benefits, difficulties and costs your Command may experience in using a CD system?  
\_\_\_Yes, use a testing department  
\_\_\_No, implement all departments at one time
- Question 13. If a pilot program for installation and conversion to a CD system can be funded, would you want your ship to participate in the program?
  - a. \_\_\_ No, please check all that apply below  
\_\_\_Manpower intensive \_\_\_Currently have CD systems onboard  
\_\_\_Operational requirements do not allow for installation in the near future  
\_\_\_Command may be decommissioned in the next 5 years
  - b. \_\_\_ Yes, please check all that apply below  
\_\_\_The Command does not have CD systems installed  
\_\_\_Ship to enter overhaul within 2 years  
\_\_\_The Command would benefit from the new technology  
\_\_\_The ship has had a poor experience with the previous system  
\_\_\_Other\_\_\_\_\_

Question 13 part "a" was used to quickly isolate those who preferred not to participate in a pilot program. Questions 9 and 10 are tabulated on Charts 5 and 6 Appendix B, respectively. Question 13 was a yes/no response used to isolate those commands that do want to participate in a pilot program if one can be funded.

## **2. Analysis of Data**

Only one respondent (1.6%), has installed a fiber optic LAN purchased with ships funds (OPTINET). This command should be consulted for lessons learned in the design and installation of the fiber optic network.

The majority of respondents of Question 9 and 10 preferred an installation to be dependent on the department (a write in response) and to implement all systems at once (Charts 5 and 6, Appendix B). The two answers conflict with Core Question 3 responses. The systems cannot be implemented all at once and still be dependent upon the department for installation. It is recommended that the installation be followed as found in Core Question 3. The installation can be a continuing effort, phasing in each department to the CD system. This modular approach has several advantages:

- exposes the CD system to the Command.
- promotes the system within the crew.
- phases in the process gradually.
- allows the isolation of bugs to be worked out without having a major adverse effect on the command.



- establishes a "lessons learned" for the other departments.
- allows each department to be a testing department for the next department scheduled for the system implementation.

Overall the majority, forty-three respondents (70.5%), preferred not to use a testing department and to implement all systems at one time. The participation in a pilot program was split in favor of a pilot program.

Thirty-three respondents (56%) indicated they wanted to participate in a pilot program. The major reason for wanting to participate were: benefitting from the technology, and the ship was scheduled to enter overhaul within two years. Because of the overwhelming reponse to Question 13, the question did not require tabulation.

Those commands which showed an interest for the pilot program should be evaluated for future systems installation. Their favorable attitude will be beneficial in the study and implementation of the CD system.

## **VI. CONCLUSIONS**

### **A. SUMMARY OF CORE QUESTIONS**

The five core questions were answered satisfactorily and the conclusions were within the capabilities of CNSL and the surface ship commanders. The following is a summary of responses to the five core questions.

#### **1. Core Question 1**

CD-ROMs are prevalent in the Atlantic Fleet. Their usage, location, and funding vary greatly.

#### **2. Core Question 2**

Despite minimal training, there is a very widespread use of CD-ROM systems.

#### **3. Core Question 3**

The Commanding Officers recommend conversion of shipboard departments in the following order:

1. Supply Department.
2. 3M.
3. Combat Systems Department.
4. Engineering Department.
5. Operations Department.
6. Navigation & Administration.
7. Deck.
8. Other areas.

Conversion in this order is seen as predominately "easy" with Engineering conversion having minor difficulty.

#### **4. Core Question 4**

Technical support and phase replacement are major concerns for Commanding Officers. The "other" concerns of Commanding Officers need further study.

#### **5. Core Question 5**

The majority of Commanding Officers want to participate in a pilot program because it would be beneficial to the command. The implementation of the system would be dependent upon the department. It is recommended that a phased installation plan be conducted utilizing Core Question 3 responses as an implementation guide.

### **B. CONCLUSIONS**

The world of information technology is a dynamic area and the Navy Officers and enlisted corps need to keep abreast of developments and improvements to help their commands excel. The use of CD-ROM technology to manage the volumes of documentation required aboard ship is a good example.

Commands should attempt to obtain CD-ROM systems and get them into the hands of their personnel. The crew needs to experiment with the system and experience its capabilities. They can only become comfortable with a CD system if they are permitted to use it, maintain it, discuss it, and conduct

training on it. It should become a command objective to integrate the CD system into the training cycle for each division. Education and use are a way of opening the system to the crew for acceptance. Familiarity will educate the crewmembers, enabling them to become more productive and proficient.

Follow on studies for improvement can concentrate on case studies of economic analysis, establishment of management or training criteria, networking, streamlining technical support, or software development for specific ships.

## APPENDIX A

1. Please indicate your ship type.

☐ AE21    ☐ AE26    ☐ AO177    ☐ AOE1    ☐ AOR1    ☐ CG47  
☐ DDG51    ☐ DD963    ☐ DD994    ☐ FFG7    ☐ LCC    ☐ LHA1  
☐ LHD1    ☐ LPH2    ☐ LPD4    ☐ LSD36    ☐ LSD41    ☐ LST1179  
☐ MCM    ☐ MSO    ☐ Other

2. Do you currently have a CD ROM system installed on your ship?

☐ Yes    ☐ No    (Please go to question 8)

3. How many CD systems do you currently have on your ship?

☐ 1    ☐ 2    ☐ 3    ☐ 4    ☐ 5    ☐ More than 5 (how many ☐ )

4. In which departments do you have CD systems? (Check all that apply)

☐ Combat Systems    ☐ Deck    ☐ Engineering  
☐ Navigation/Administration    ☐ Operations    ☐ Supply  
☐ 3M    ☐ Other

5. How did you obtain the CD systems?

☐ Purchased with own funds    ☐ Issued by SURFLANT  
☐ Other \_\_\_\_\_

6. On an daily basis, indicate how many individual hours your crew uses a CD system?

☐ 1-2 Hours    ☐ 2-4 Hours    ☐ 4-6 Hours    ☐ > 6 hours  
☐ Not used daily

7. How many hours of formal training have been conducted in the use, management, and maintenance of your CD system(s)?

☐ 1-4 Hours    ☐ 4-8 Hours    ☐ 1-2 days

☐ No formal training    ☐ Other \_\_\_\_\_

8. The Navy is currently working towards "paperless" ships. Please rank the departments (first to last) where you would convert the documentation for a CD system.

☐ Combat Systems    ☐ Deck    ☐ Engineering

☐ Navigation/Administration    ☐ Operations    ☐ Supply    ☐ 3M

☐ Other \_\_\_\_\_

9. When would you prefer to install a CD system in a department?

☐ Major overhaul period    ☐ Intermediate availability

☐ Other, please specify when \_\_\_\_\_

10. Would you prefer to use one department as a test site to determine the benefits, difficulties and costs your Command may experience in using a CD system?

☐ Yes, use a testing department

☐ No, implement all departments at one time

11. Please indicate the difficulty in converting your departments to CD technology, a '1' being the easiest and a '5' being the hardest.

☐ Combat Systems    ☐ Deck    ☐ Engineering    ☐ Operations

☐ Navigation/Administration    ☐ Supply    ☐ 3M

12. What concerns do you have concerning CD technology.  
Please check all that apply.

☐ No phase replacement for older systems

☐ Security violations ☐ Hidden costs

☐ Lack of technical support ☐ No management criteria

☐ Loss of future funding ☐ Too costly to maintain

☐ CD technology will be surpassed ☐ Other\_\_\_\_\_

13. If a pilot program for installation and conversion to a  
CD system can be funded, would you want your ship to  
participate in the program?

a. ☐ No, please check all that apply below

☐ Manpower intensive ☐ Currently have CD systems onboard

☐ Operational requirements do not allow for installation in  
the near future

☐ Command may be decommissioned in the next 5 years.

☐ Other\_\_\_\_\_

b. ☐ Yes, please check all that apply below

☐ The Command does not have CD systems installed

☐ The Command would benefit from the new technology

☐ Ship to enter overhaul within 2 years

☐ Ship has had a poor experience with previous systems

☐ Other\_\_\_\_\_

Thank you for your time and consideration in completing the  
survey. Please place the completed survey in the self  
addressed, stamped envelope and mail.

# APPENDIX B

Table 1 Ship Types

## Question 1

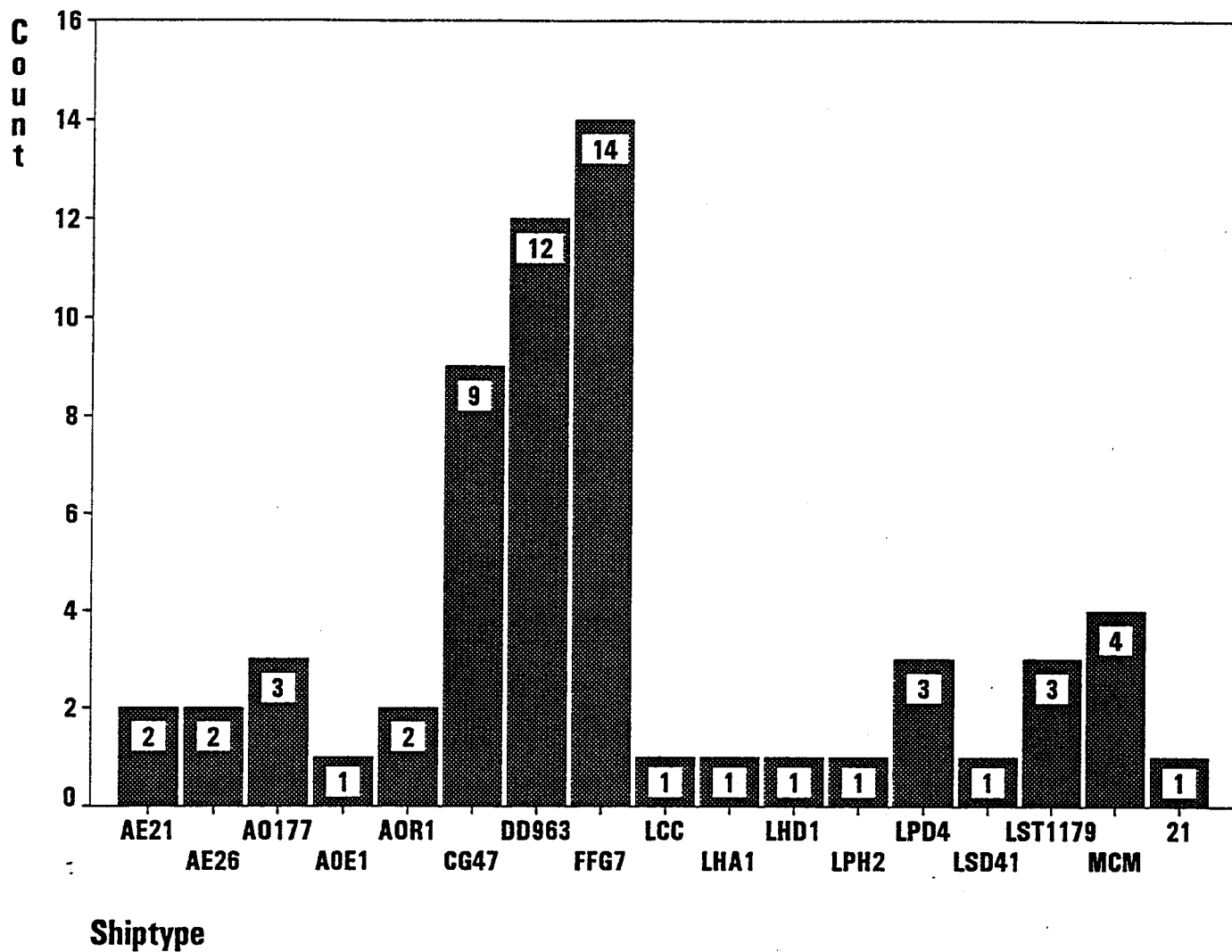




Table 2 Number of CD-ROMs Installed

### Question 3

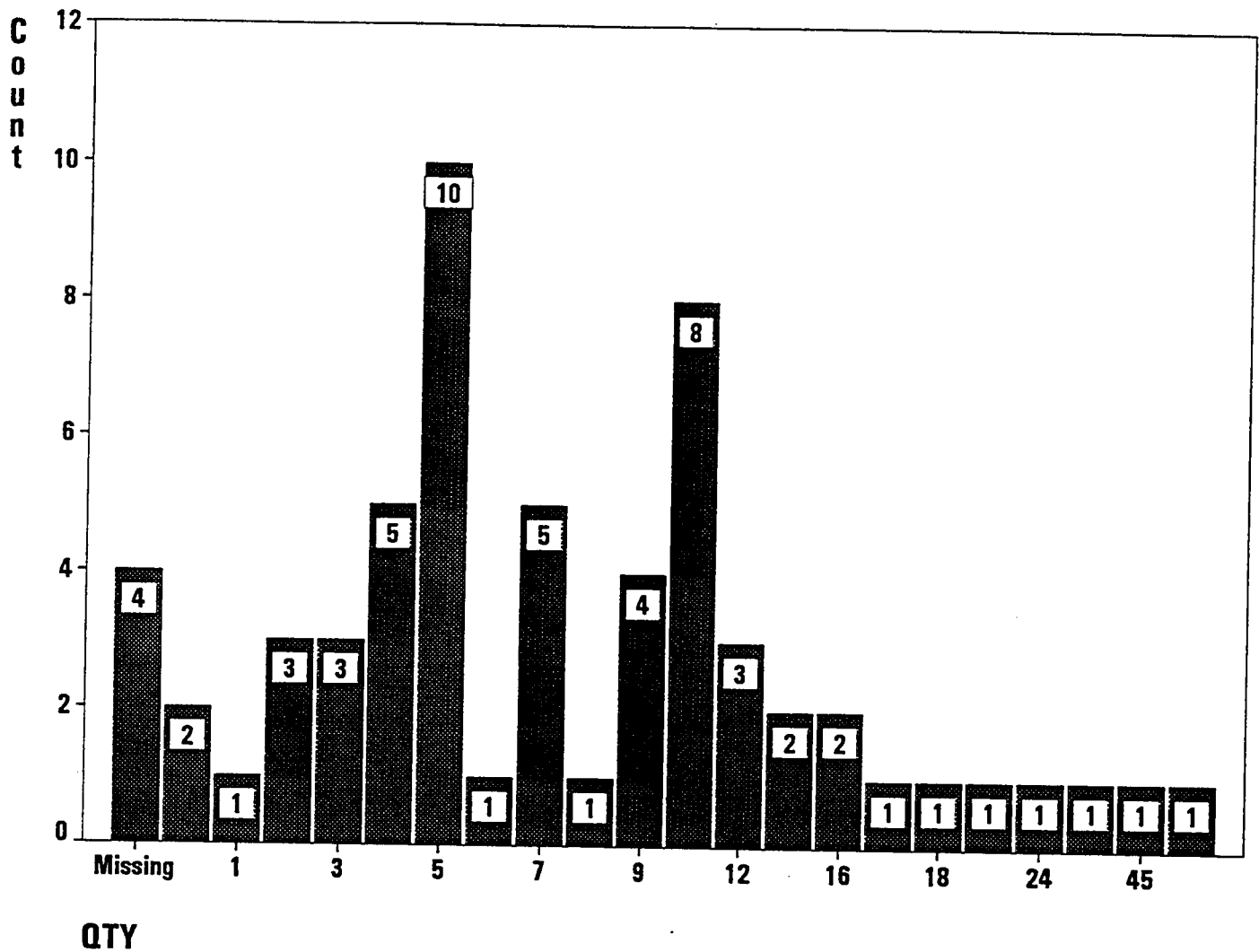


Chart 1 Summary of CD-ROM by Department

Question 4

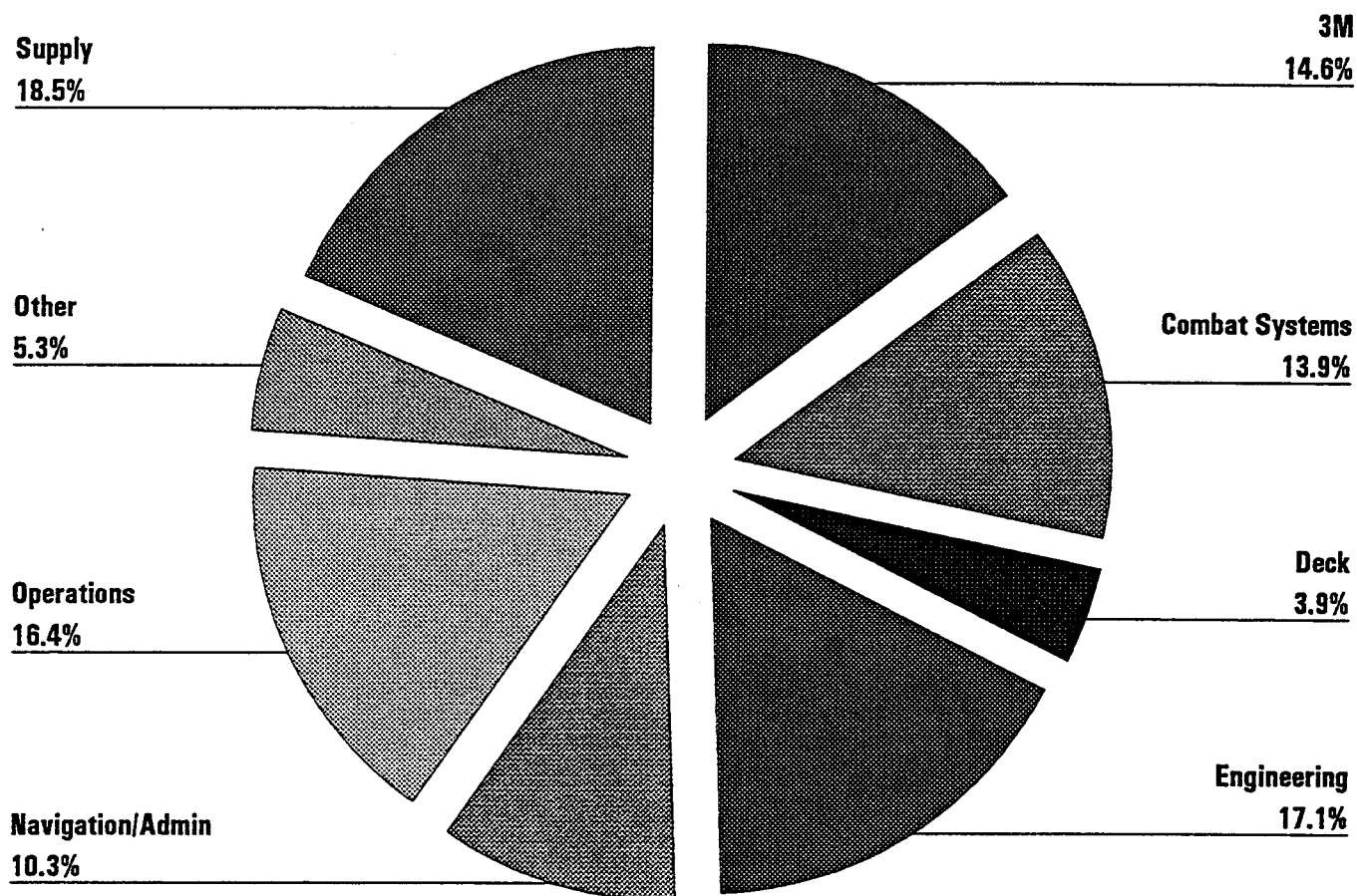


Chart 2 Purchase of CD-ROMs

## Question 5

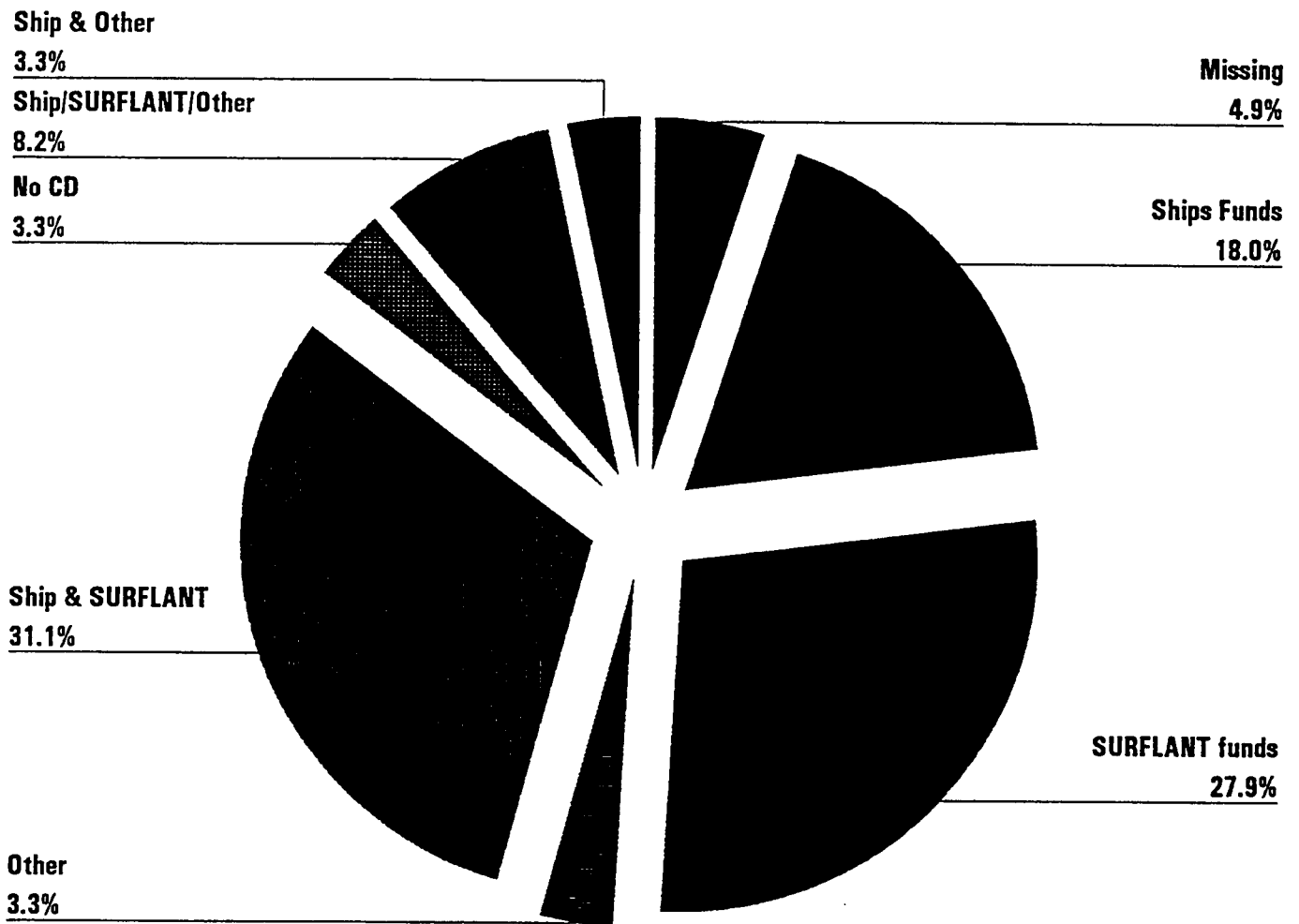
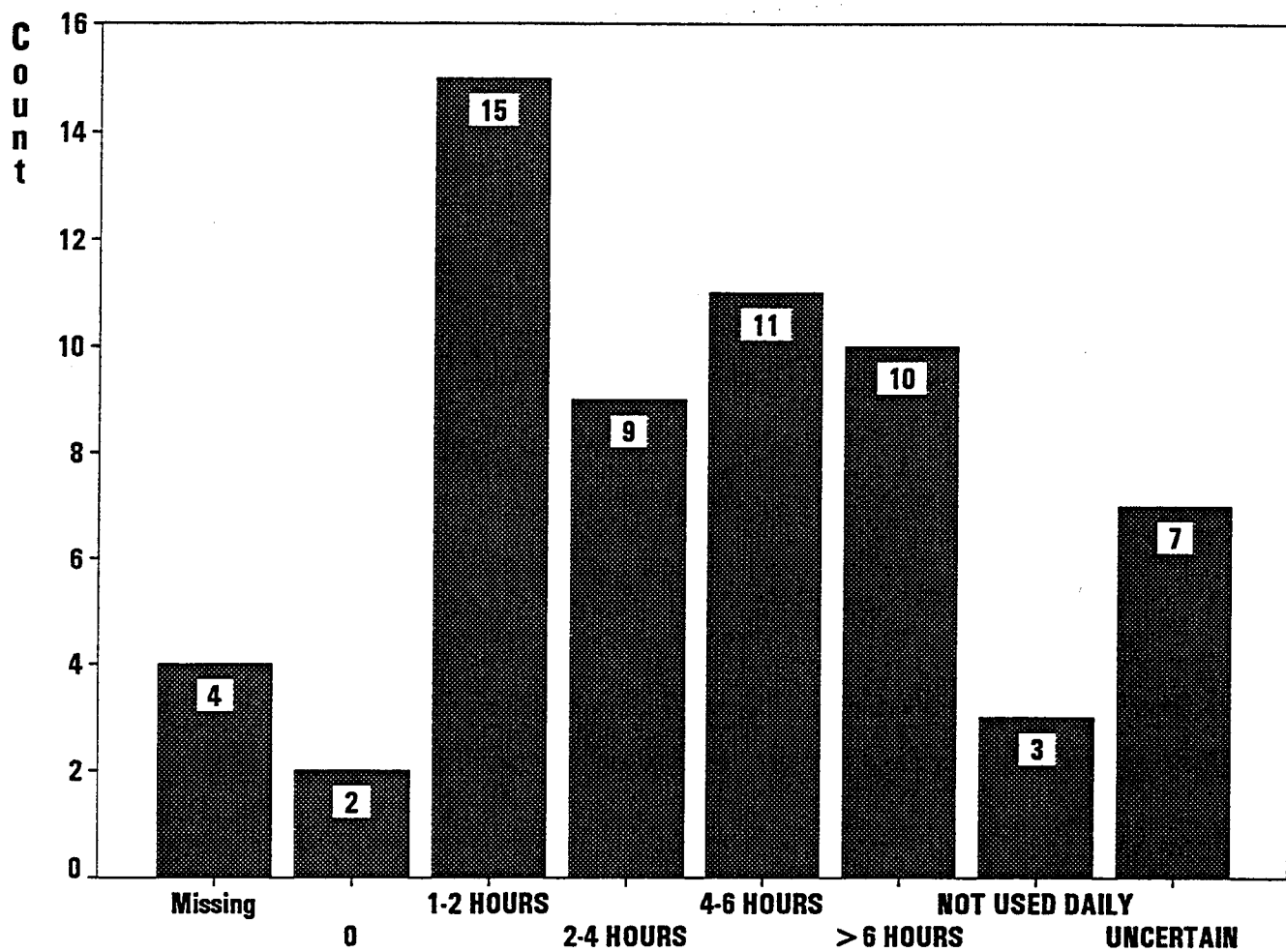


Table 3 Daily Use of CD-ROMs

**Question 6**



**MANHOURS**

Chart 3 Training

Question 7

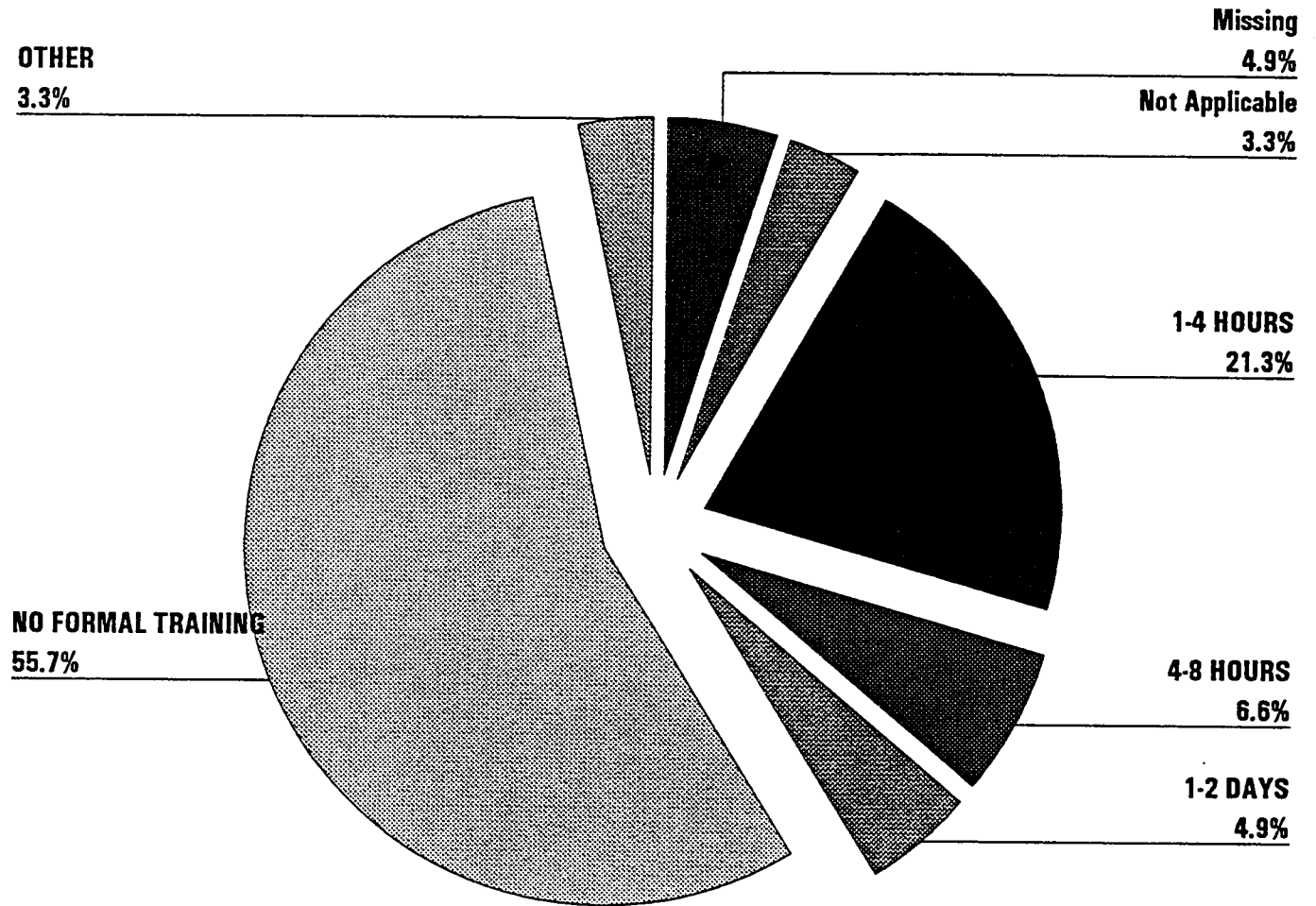
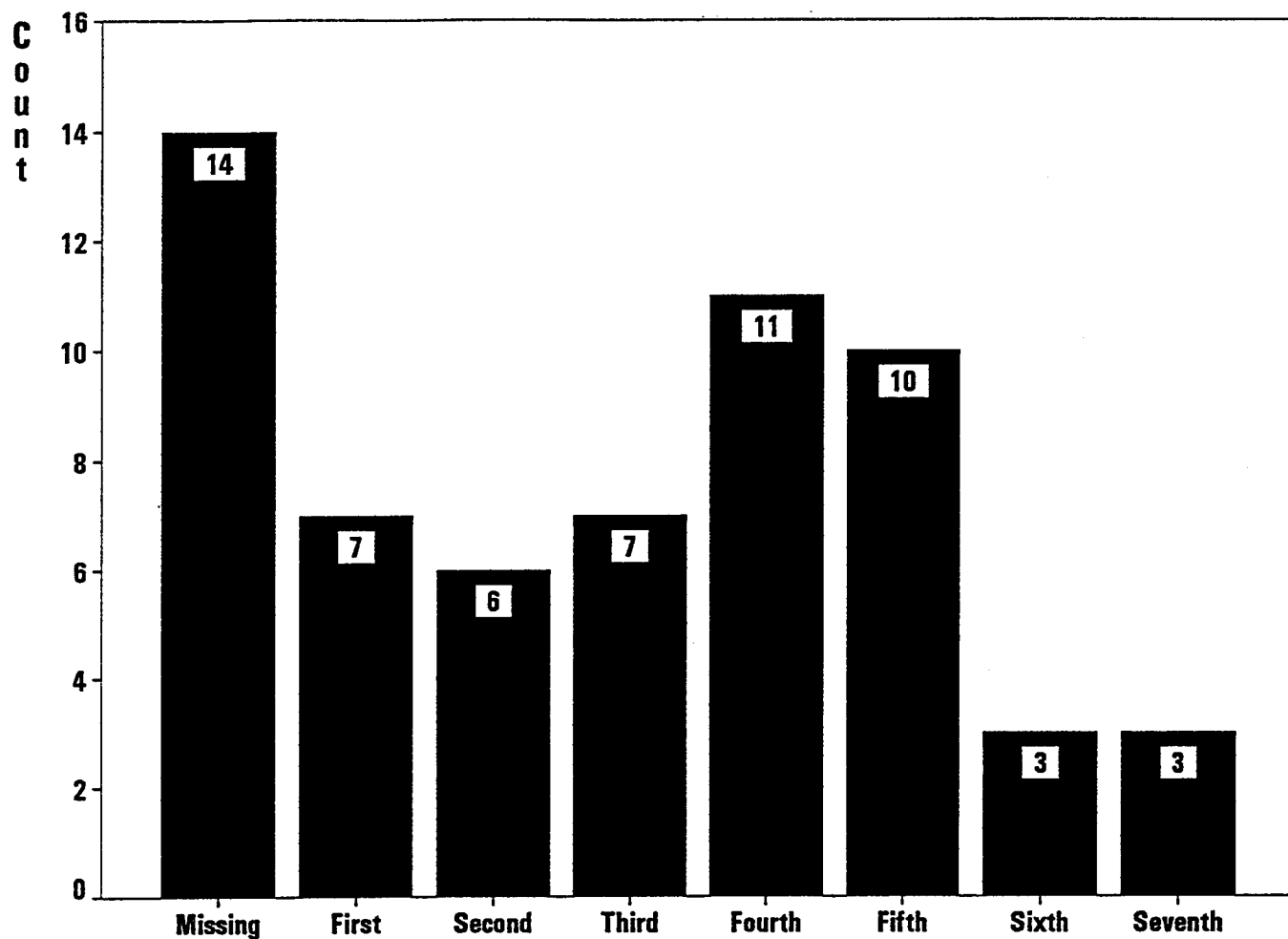


Table 4a Combat Systems Conversion

**Question 8**



**Combat Systems Conversion Order**

Table 4b Deck Conversion

**Question 8**

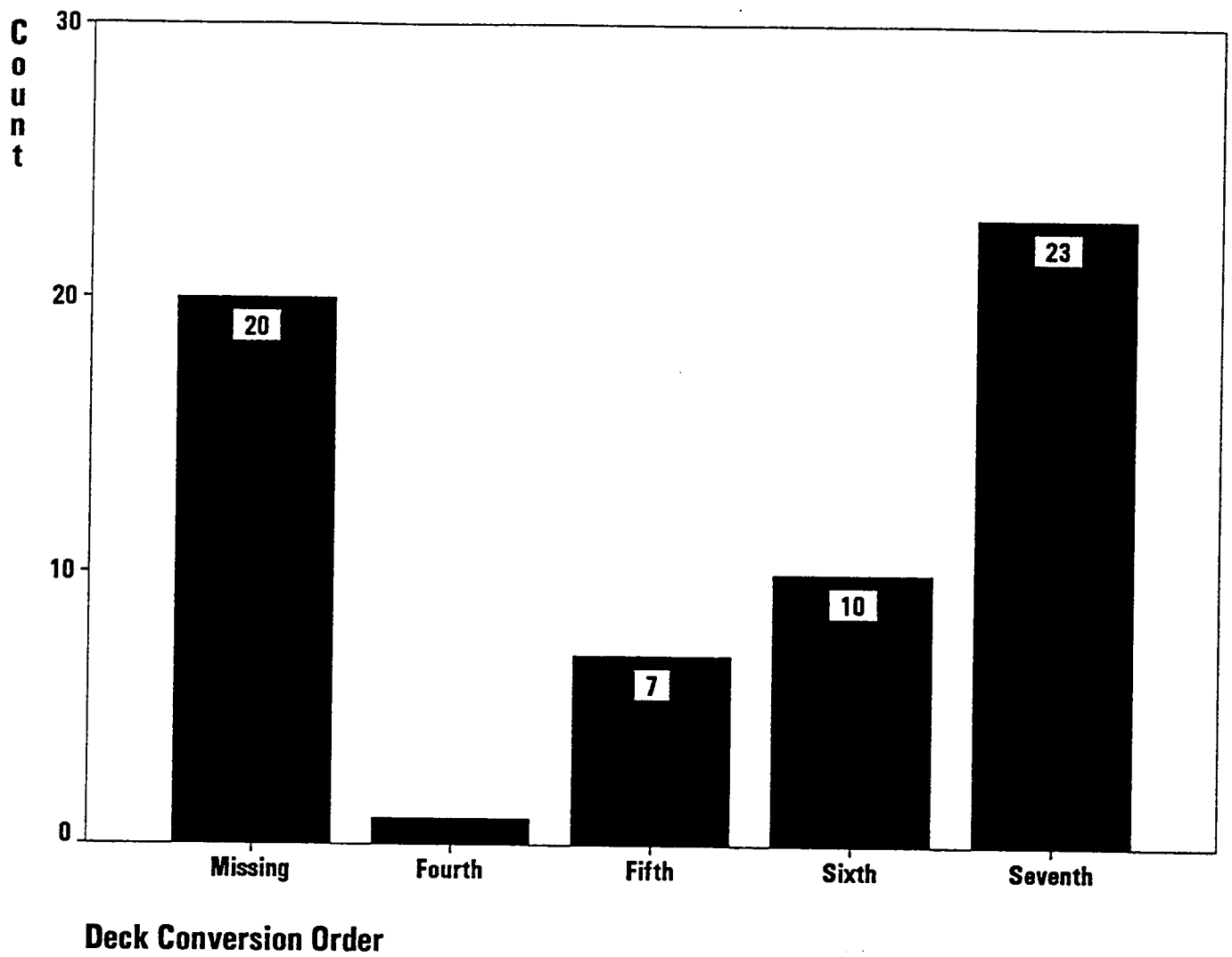
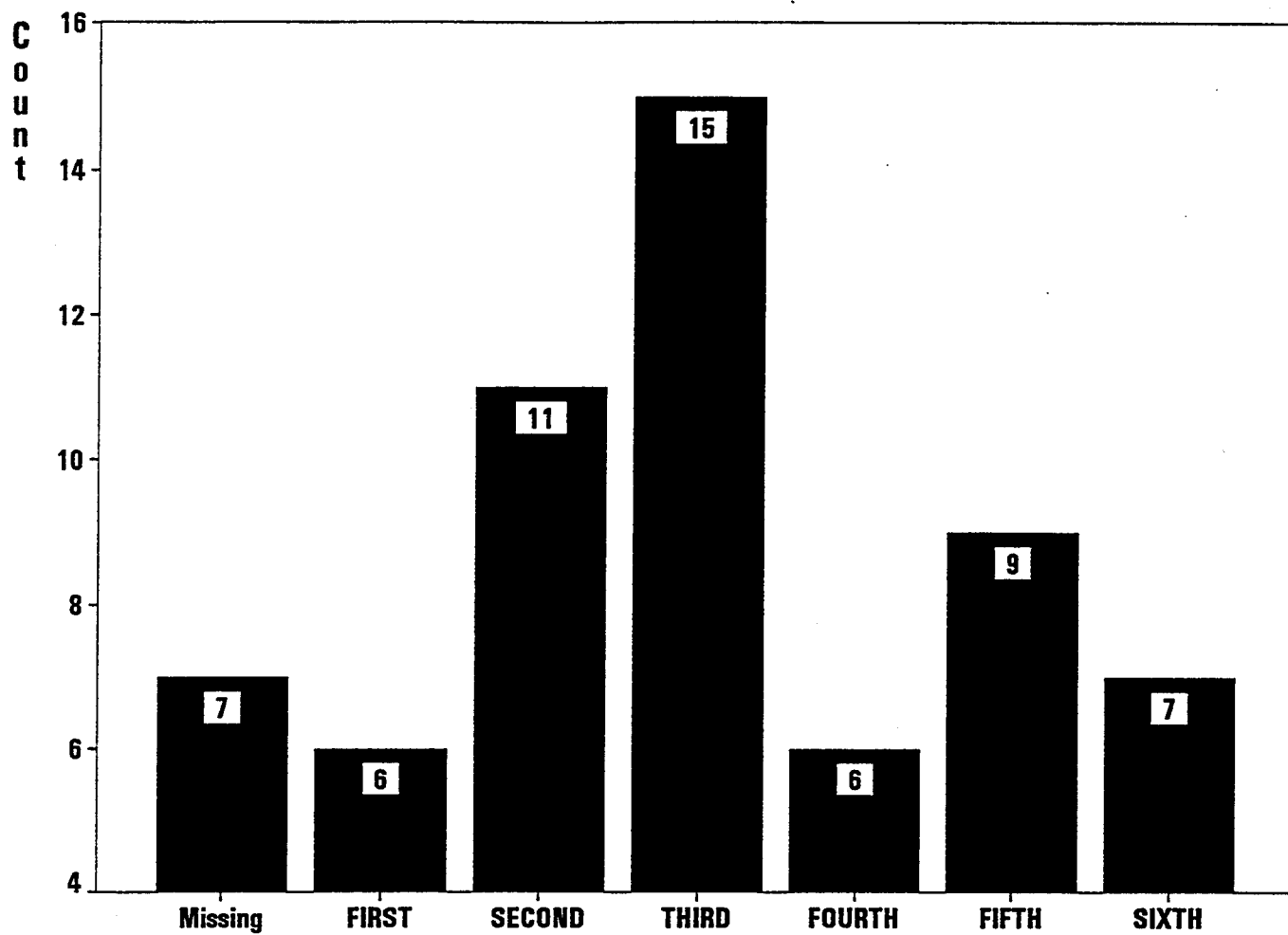


Table 4c Engineering Conversion

**Question 8**



**Engineering Conversion Order**



Table 4d Operations Conversion

**Question 8**

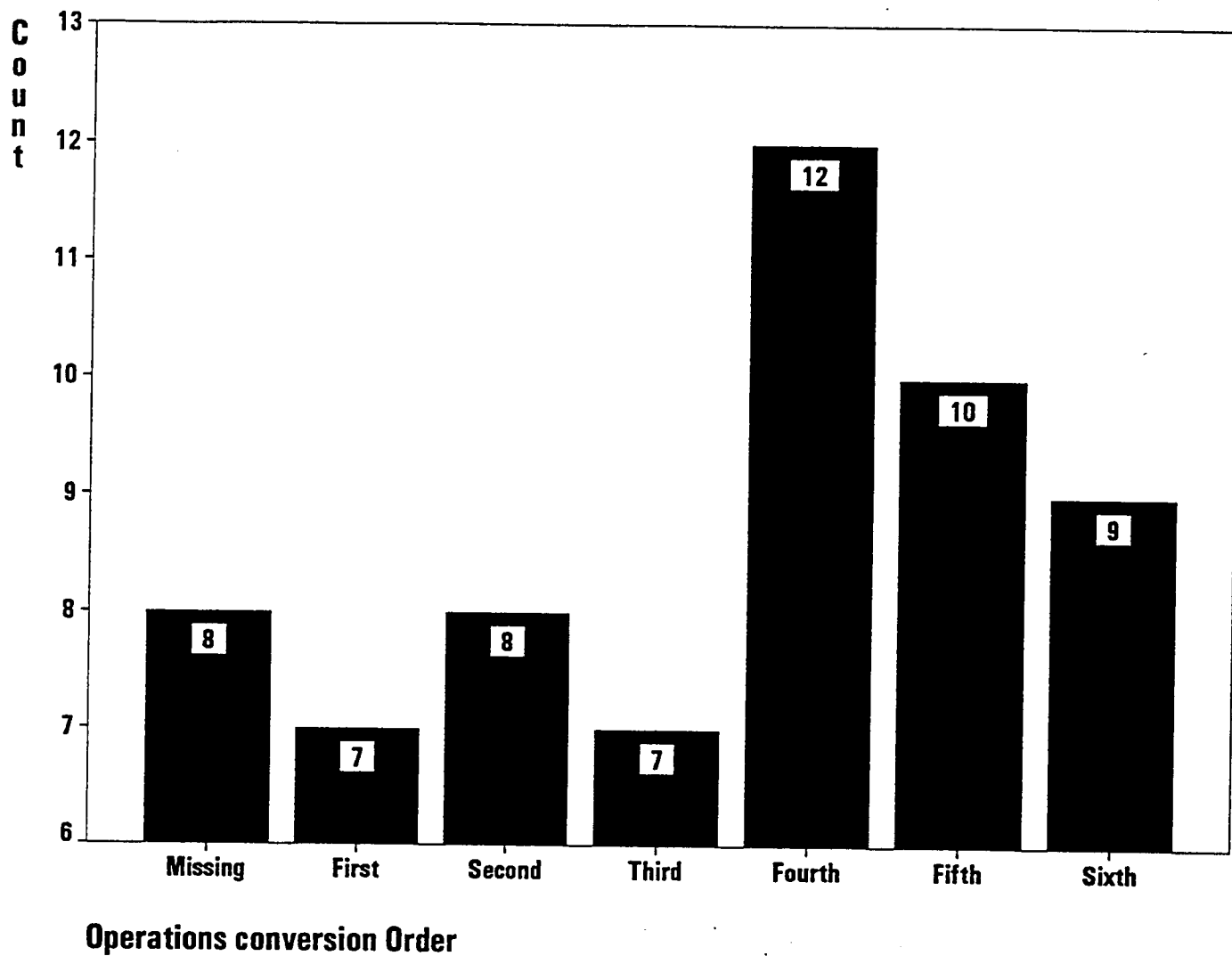


Table 4e Supply Conversion

**Question 8**

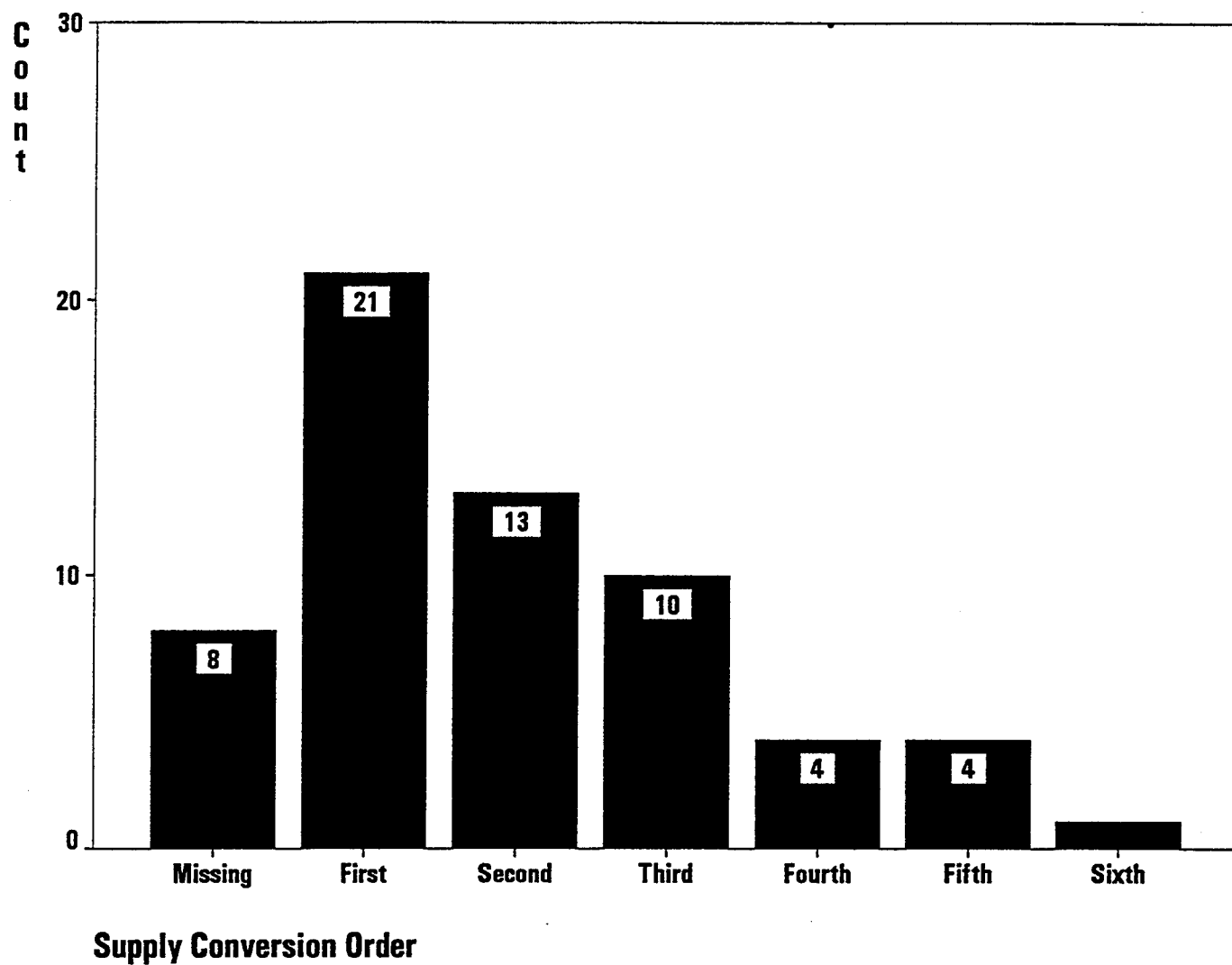


Table 4f 3M Conversion

**Question 8**

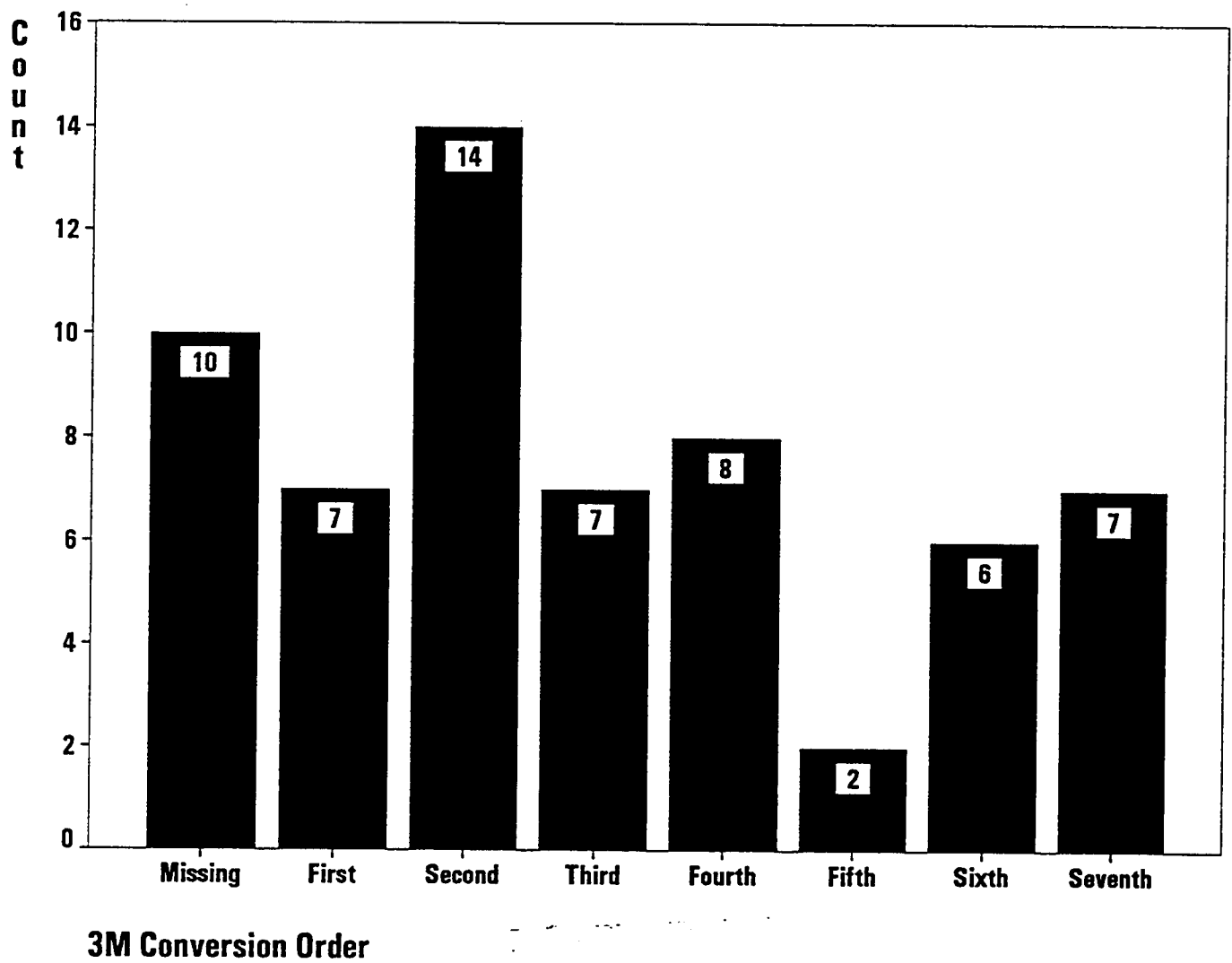
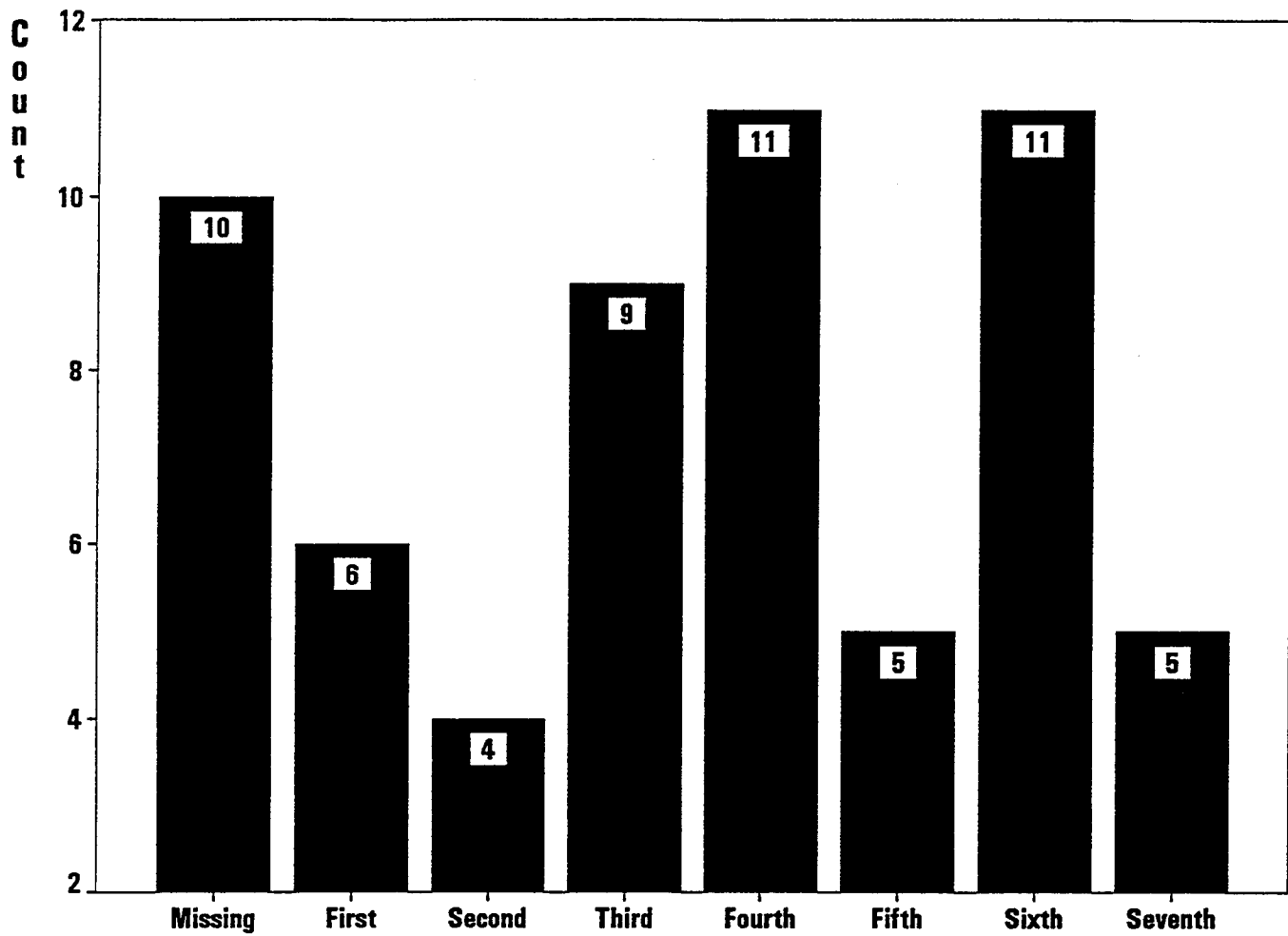


Table 4g Navigation & Administration Conversion

**Question 8**



**Navigation & Administration Conversion Order**

Table 4h Other Conversions

**Question 8**

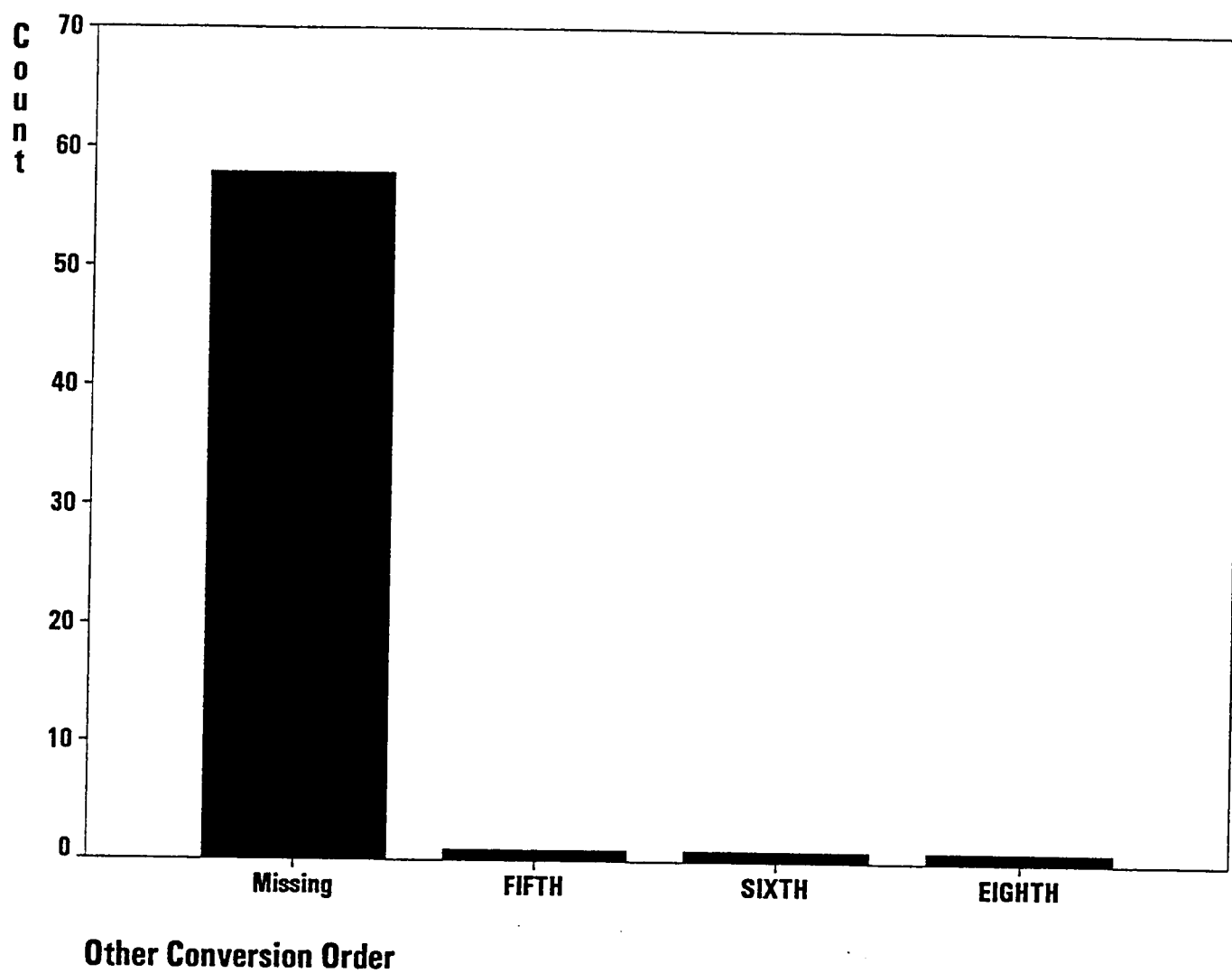
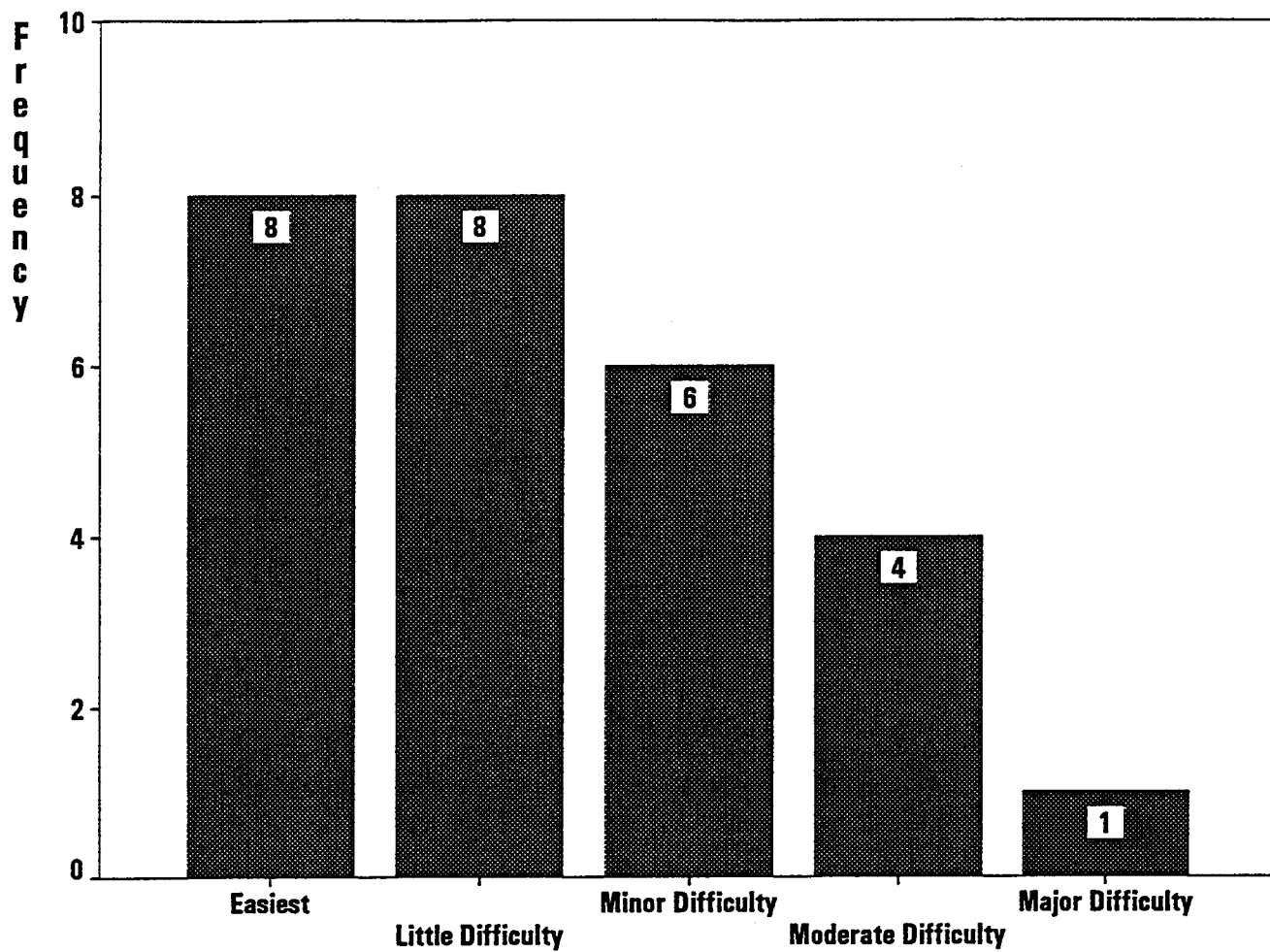


Table 5a Ease of Combat Systems Implementation

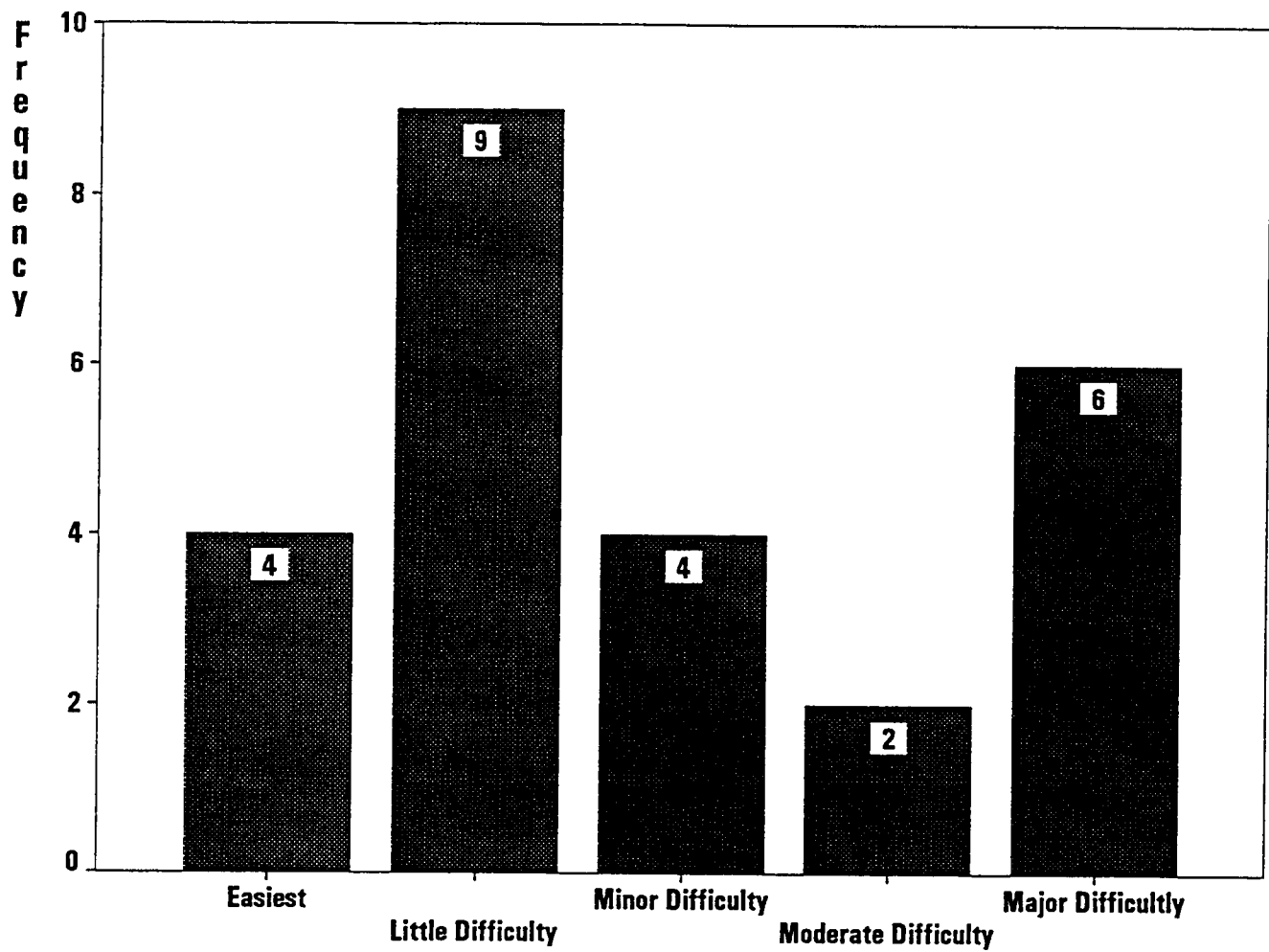
**Question 11**



**Combat Systems Implementation**

Table 5b Ease of Deck Implementation

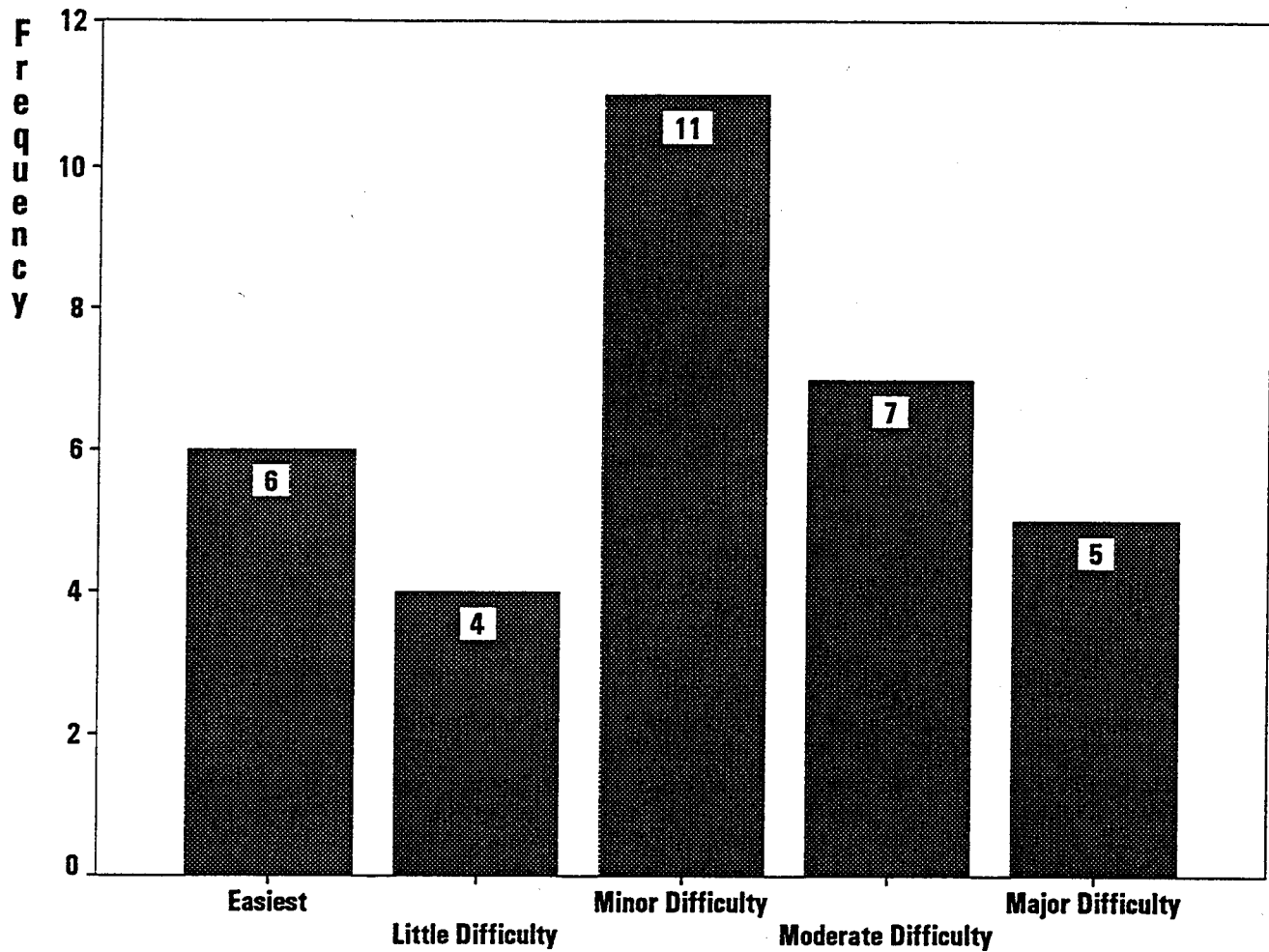
**Question 11**



**Deck Implementation**

Table 5c Ease of Engineering Implementation

**Question 11**

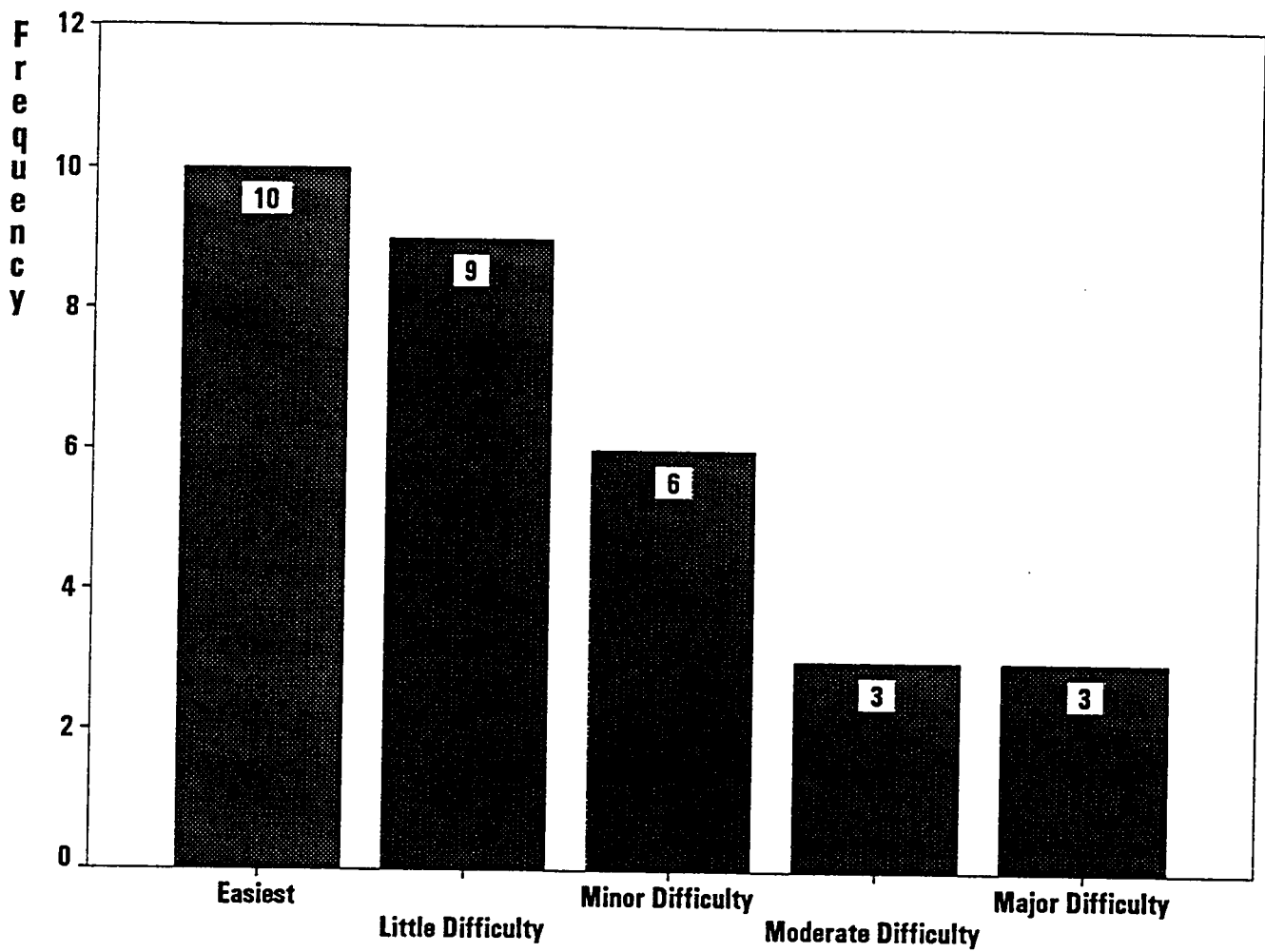


**Engineering Implementation**



Table 5d Ease of Operations Implementation

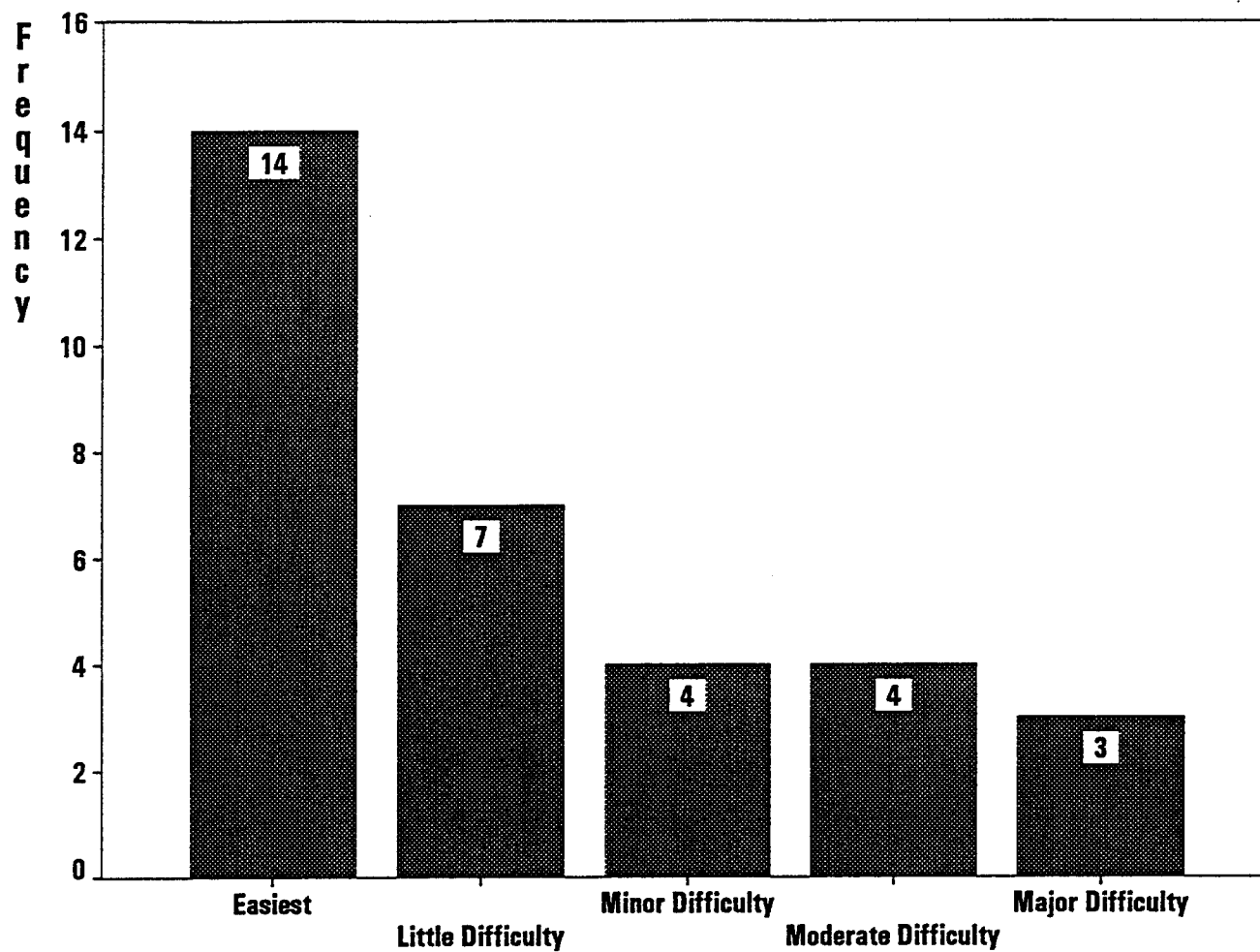
**Question 11**



**Operations Implementation**

Table 5e Ease of Supply Implementation

**Question 11**



**Supply Implementation**

Table 5f Ease of 3M Implementation

**Question 11**

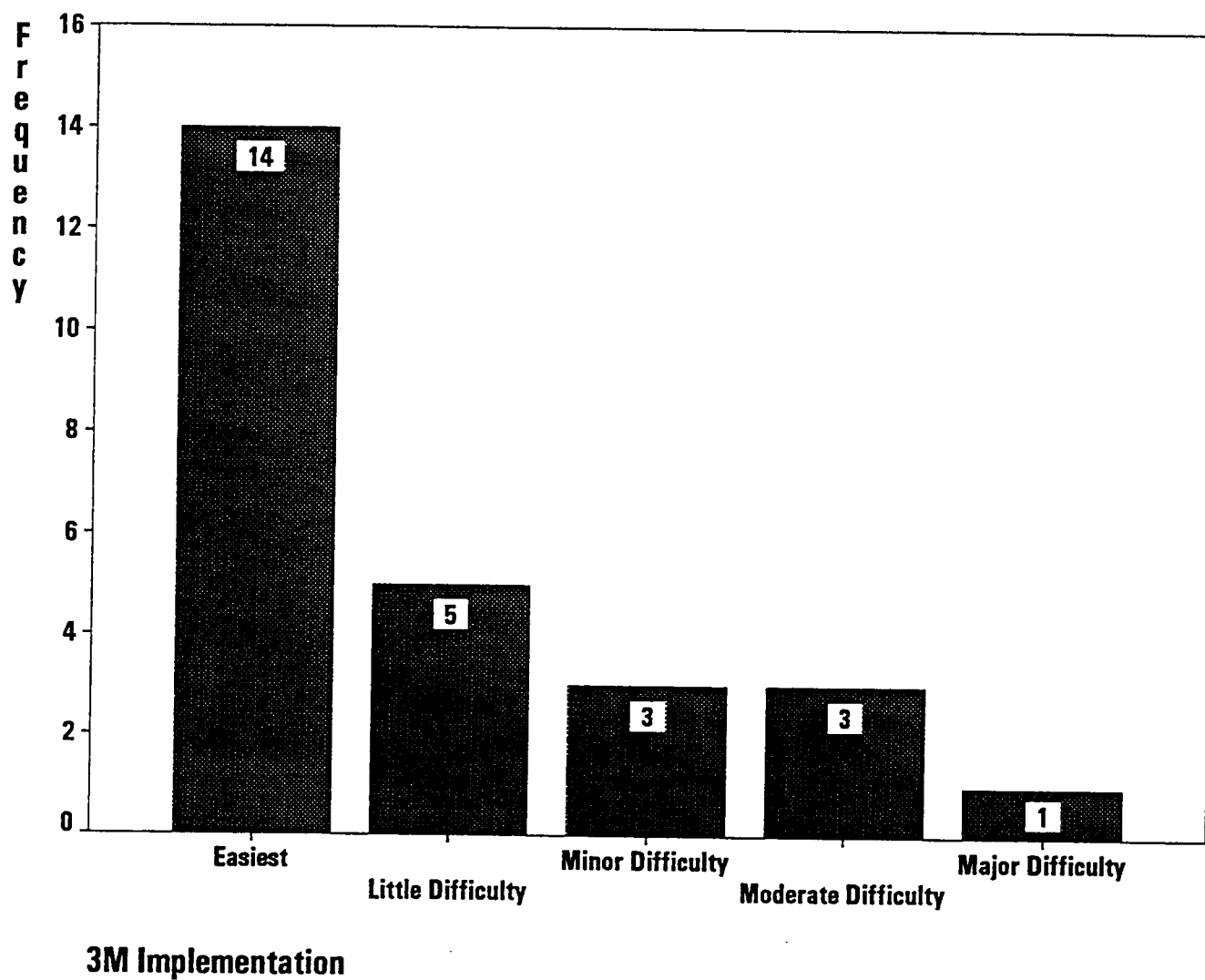
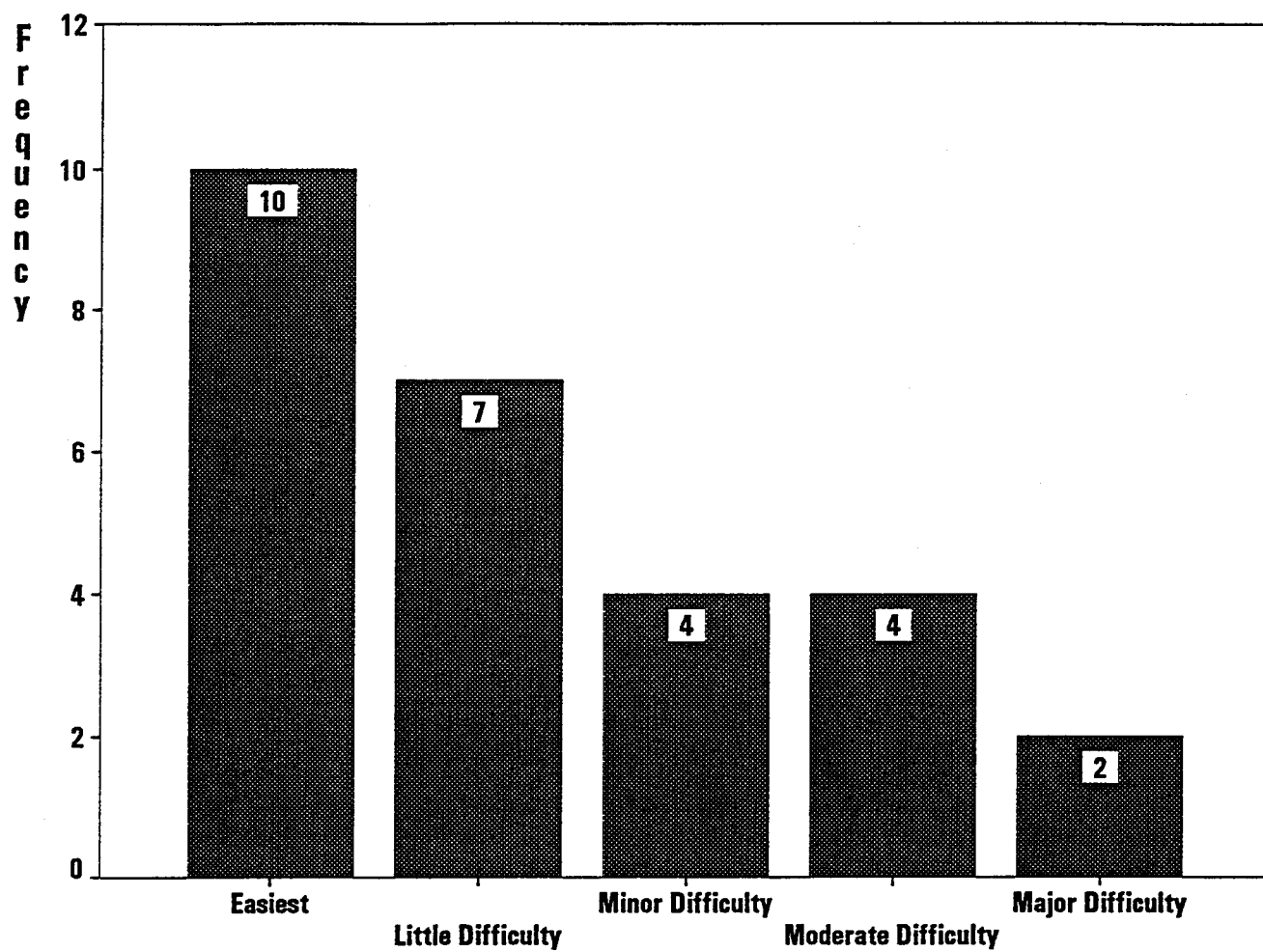


Table 5g Ease of Navigation & Administration Implementation

**Question 11**



**Navigation & Administration Implementation**

Chart 4 Commanding Officers Concerns

**Question 12**

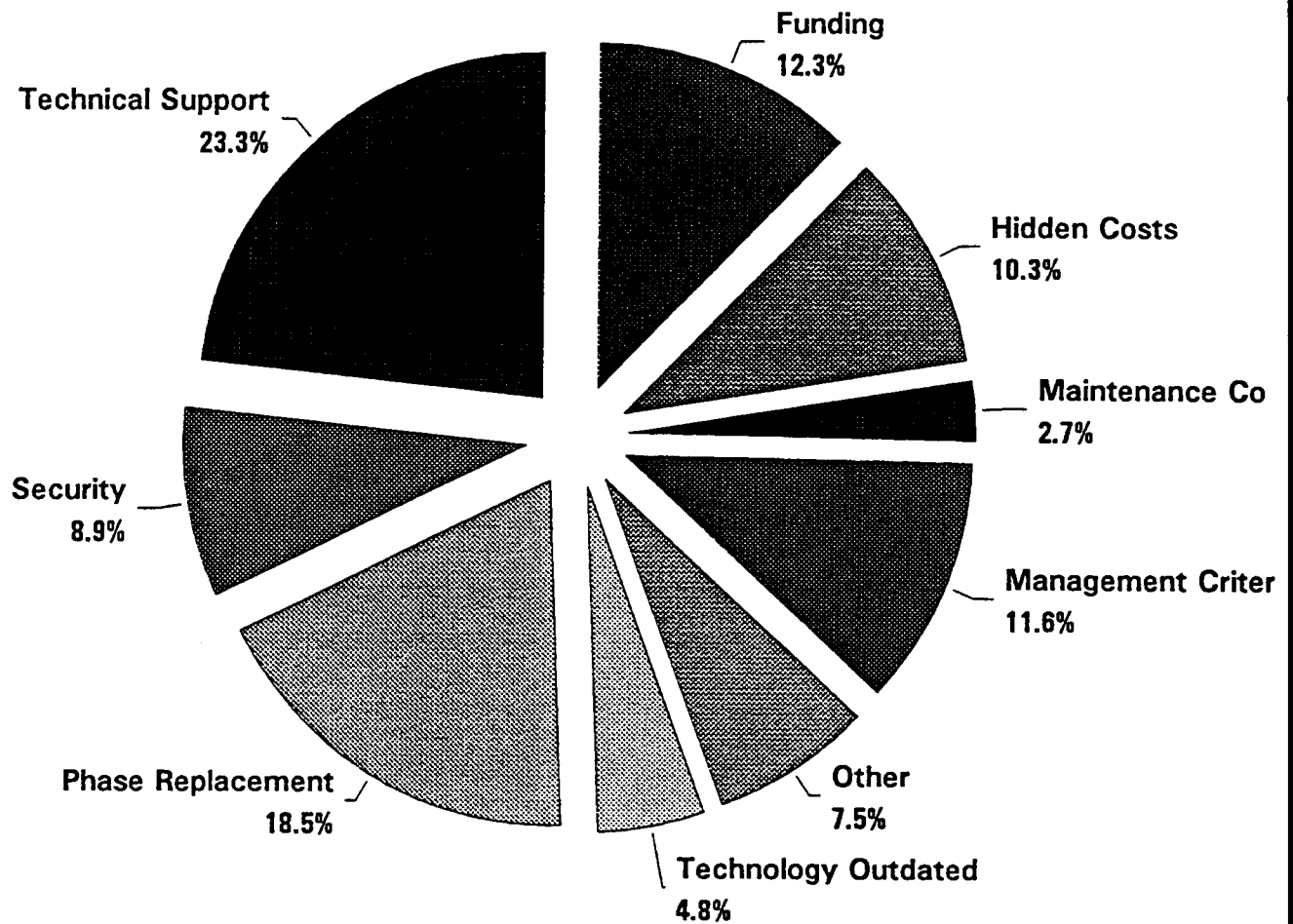


Chart 5 Installation Preferences

Question 9

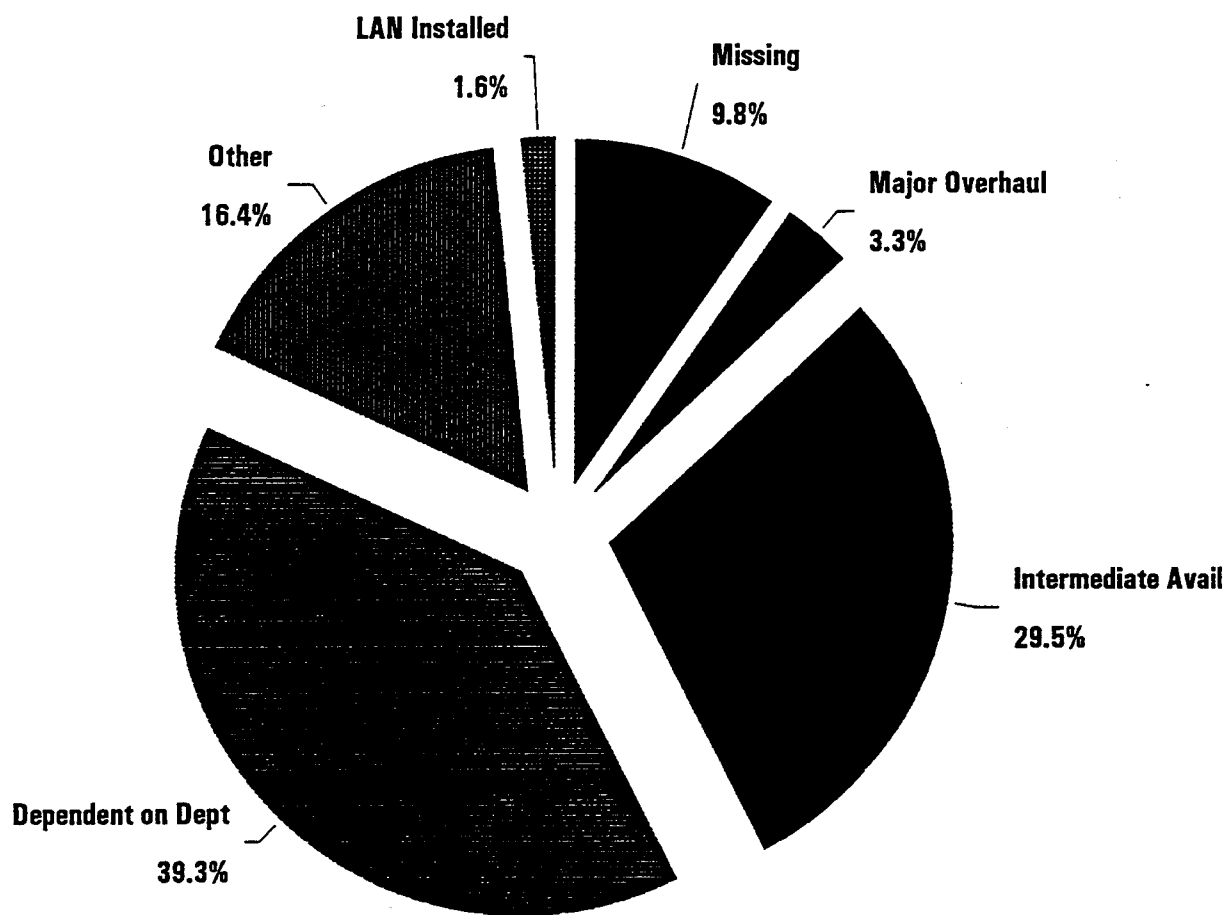
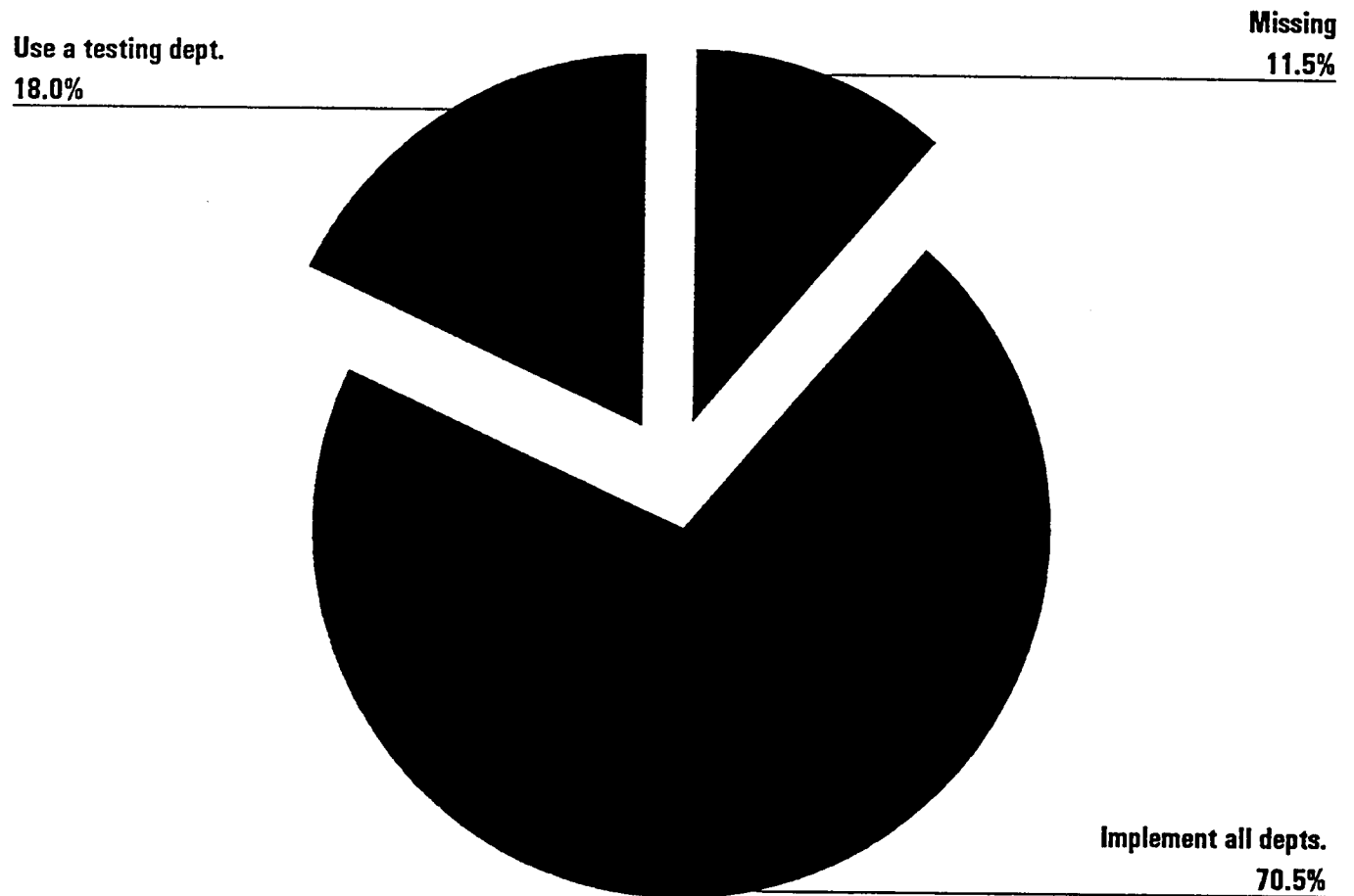


Chart 6 Use of a Test Site

**Question 10**



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